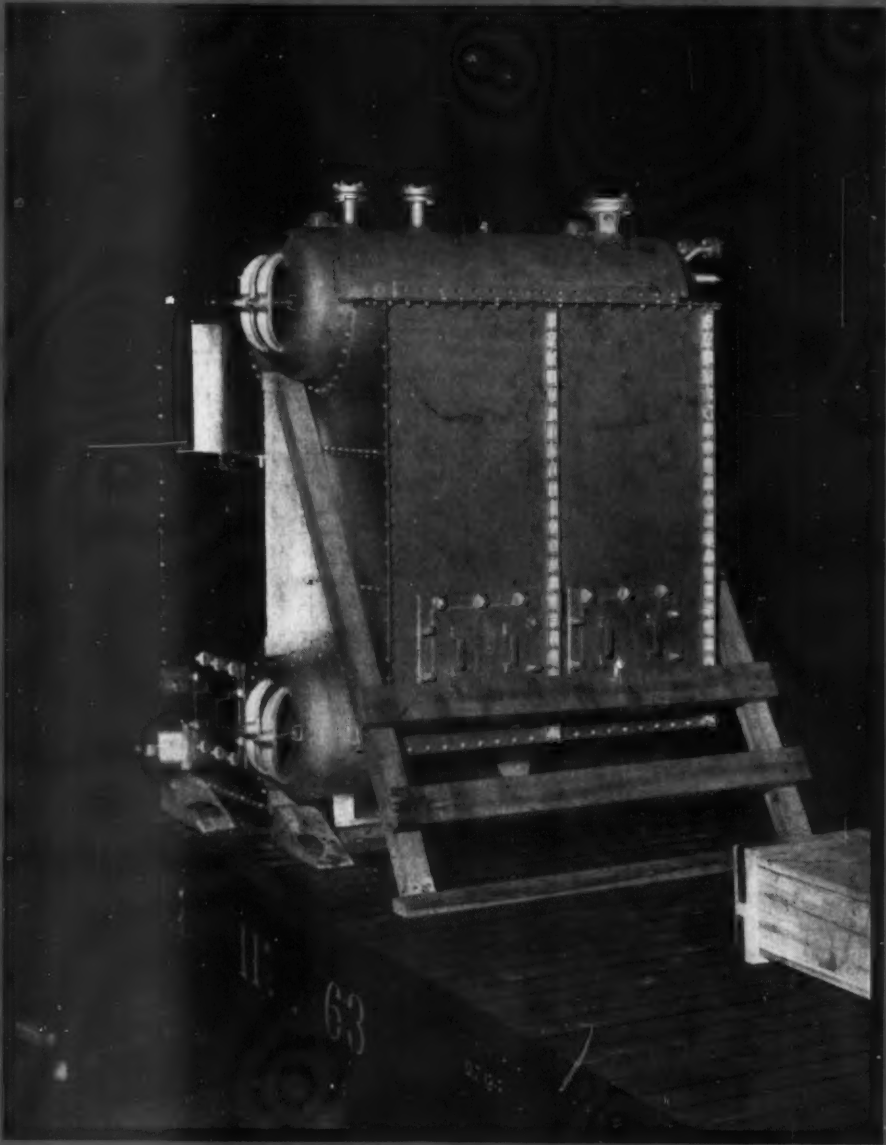
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 12, No. 11 MAY, 1941 25c a copy

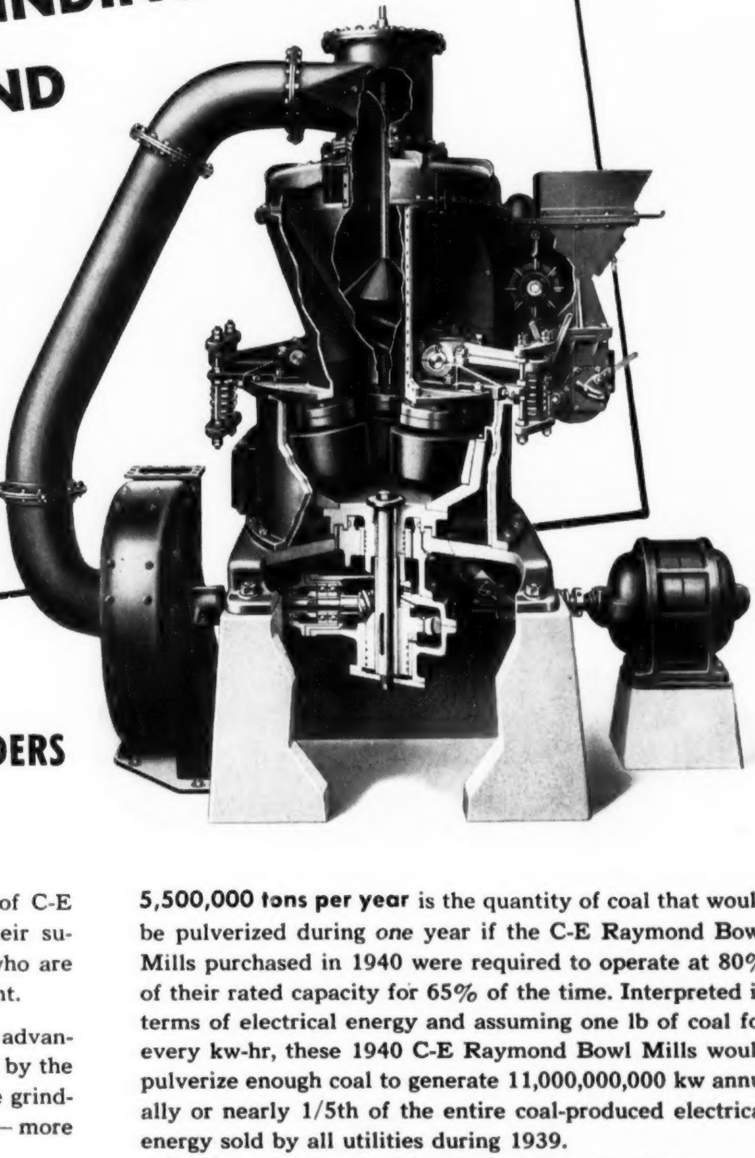


Steam-generating unit of 5000 lb per hr output, occupying approximately 5 x 6 x 8 ft and suitable for portable use in defense

2,412,800 ~~1,137,250~~ LB OF COAL PER HOUR

AGGREGATE GRINDING CAPACITY OF C-E RAYMOND BOWL MILLS

Purchased during 1940 ~~1939~~



P. S. 65% ~~38%~~ WERE REPEAT ORDERS

A comparison between 1940 and 1939 purchases of C-E Raymond Bowl Mills emphasizes in two ways their superiority as expressed by the operating engineers who are responsible for the selection of pulverizer equipment.

1. That more and more plants are recognizing the advantages of design, construction and operation provided by the C-E Raymond Bowl Mill is proved by the aggregate grinding capacity of 2,412,800 lb per hr sold during 1940 – more than double the substantial volume sold in 1939.

2. That plants which are operating C-E Raymond Bowl Mills and are in the best position to appraise their efficiency, economy and reliability *continue to buy them* is proved by the fact that 65% of the mills purchased during 1940 were *repeat* orders!

5,500,000 tons per year is the quantity of coal that would be pulverized during *one* year if the C-E Raymond Bowl Mills purchased in 1940 were required to operate at 80% of their rated capacity for 65% of the time. Interpreted in terms of electrical energy and assuming one lb of coal for every kw-hr, these 1940 C-E Raymond Bowl Mills would pulverize enough coal to generate 11,000,000,000 kw annually or nearly 1/5th of the entire coal-produced electrical energy sold by all utilities during 1939.

In view of the self-evident importance of pulverizer performance to over-all efficiency, plants which are now contemplating the purchase of pulverized-coal-fired boiler installations should investigate the numerous reasons of design and construction responsible for this decided preference in favor of the C-E Raymond Bowl Mill.

A-589

COMBUSTION ENGINEERING

200 Madison Avenue New York, New York

C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME TWELVE NUMBER ELEVEN

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FOR MAY 1941

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

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Published monthly by COMBUSTION PUBLISHING COMPANY, INC., a subsidiary of COMBUSTION ENGINEERING COMPANY, INC., 200 Madison Ave., New York; Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer. It is sent gratis to consulting and designing engineers and those in charge of steam plants from 500 rated boiler horsepower up. To others the subscription rate, including postage, is $2 in the United States, $2.50 in Canada and Great Britain and $3 in other countries. Single copies: 25 cents. Printed in U. S A. Publication office, 200 Madison Avenue, New York. Issued the middle of the month of publication.

Member, Controlled Circulation Audit, Inc.

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EDITORIAL

Census Figures on Industrial Power

Statistics have now been made available from the Sixteenth Decennial Census of Manufacturers concerning installed prime mover capacity, electric motors and purchased power in American industry, as of 1939. This survey was the first since 1929 and shows some interesting trends, despite the vicissitudes of intervening years.

Although the number of establishments using power declined from nearly 211,000 to 181,000 during this period, the aggregate installed prime mover capacity increased $5^1/_2$ per cent, to 21,266,557 horsepower, the number of motors increased 30.8 per cent, and over 21 per cent more electrical energy was purchased than in 1929. This would indicate not only a continued trend toward further electrification of industry, but also that the average size of establishment had increased. Slightly more than a third of the motors are run by privately generated power, although the rates of increase in the number of motors run by privately generated power and by purchased power were practically the same. Factories having their own plants reported 65.6 per cent of the power used to drive electric motors and that about 90 per cent of the capacity was actively in use. While this may seem to provide a small margin of reserve capacity, it is not surprising when one considers the ever-increasing reliability of units and the fact that many of these plants depend to a greater or lesser extent upon breakdown connections with utility service.

Confirmation of the trend toward the employment of steam turbines in industrial plants is found in the fact that 70 per cent of the electric generators installed are driven by this type of prime mover, which represents a gain of over 46 per cent in capacity during the decade, whereas the use of steam engines declined 31.9 per cent.

As interesting as these figures are, it is regrettable that those directing the Census did not see fit to include statistics on steam-generating capacity, for in most process industries the use of steam equals or transcends that of electric power in importance and as an index of industrial activity and trends.

Uniform Abbreviations and Symbols

The American Standards Association has lately issued a 1941 revision of its standards covering abbreviations and symbols for terms used in engineering and scientific literature. These standards, originally brought out in 1932, have been approved by the sponsor organizations consisting of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Society of Civil Engineers, the Society for the Promotion of Engineering Education and the American Association for the Advancement of Science. The abbreviations are issued in a single pamphlet, and symbols are printed in separate pamphlets each covering a particular field.

Widespread adherence to these standards would be most desirable, aside from their use in papers and publications of the sponsor societies. While they are now being followed to a greater or lesser extent by many independent publications, their application is by no means general, particularly as concerns engineering and scientific books.

Admittedly, it is not always easy to edit according to rules and individual editorial preference is hard to combat. This, however, need not affect the decision of when to use, or not to use, abbreviations; but when they are employed there is little excuse for not following the accepted standards. As to symbols, the situation is even more important, for much confusion often results from the promiscuous selection of different symbols to represent the same thing.

Aside from the editorial content of publications, it would be well if the practice were to be followed in the preparation of advertisements, in general engineering work, in the writing of specifications, and in correspondence pertaining to technical matters.

Obviously, general adoption of such a uniform nomenclature is a slow process but it could be hastened through the cooperation of publishers, authors, educational institutions and business organizations in the engineering field.

Improved Boiler Performance

A perusal of the recently issued Prime Movers Report on "Boilers and Combustion," especially the statements by operating companies, indicates that much of the trouble incident to the inauguration of high-temperature, high-pressure equipment a few years back has been definitely overcome. This is shown by the greatly improved reliability of later units and their continuous operation for long periods.

Specifically, some of the minor difficulties still encountered are occasional tube failures, variously attributed to circulation or to inadequate feedwater treatment, tube-seat and handhole leakage, gage-glass failures and some fouling of air preheaters under unfavorable operating conditions. Carryover appears to be controlled more effectively and it is the Committee's opinion that the degree of turbine-blade fouling depends more upon the character of the solids carried over than the quantity. Excessive slag formation, in some cases, has reduced the heat-transfer rates below design figures and thus made the gas temperatures higher than expected.

On the whole, the report is encouraging and is especially gratifying at a time when such units are likely to be called upon for continuous service to meet the present and anticipated abnormal power demands.

High Spots of the Midwest Power Conference

A diversified program was presented including papers on power supply for national defense, power equipment design trends, steam turbine developments, supply of steam and interchange of power between a utility and industrial plants, forced-circulation boilers, federal hydro developments, variable-speed auxiliary drives, instruments and controls, and feedwater conditioning.

WITH a registration of between six and seven hundred and a well-balanced program of papers, the 1941 Midwest Power Conference, at the Palmer House, Chicago, on April 9 and 10, ranked among the most successful of these annual events sponsored by the Illinois Institute of Technology with the cooperation of several midwestern colleges and the local sections of engineering societies.

Power and National Defense

In tune with the times, there were several papers and talks dealing with the adequacy of power for the national defense program, from the standpoints of public utility supply, federal power developments to meet the demands of bulk power for the manufacture of aluminum and electric furnace work, and means for attaining additional capacity with existing industrial power plants.

Speaking at a luncheon meeting **Major Charles W. Leihy** expressed the opinion that the capacity and characteristics of existing power systems, plus the vast construction program now under way by the utilities, would provide ample protection against any general power shortage, especially as present-day power systems have considerable resiliency due to existing load factors of about 35 per cent. While there are undoubtedly places where more capacity is imperative these conditions are being met by the seven million kilowatts of additional capacity that will be available by the end of 1942, thus bringing the total capacity for public use up to over 46 million kilowatts. This capacity is represented by some 900 large modern power stations, supplemented by numerous smaller plants, to a considerable extent integrated by transmission networks which have grown up largely on an economic basis.

As a further defense measure, Mr. Leihy suggested that operators be trained not only for rapid service restoration, as they are today, but that plans be worked out for priority of such restoration to meet possible wartime conditions.

With regard to the future, the author expressed concern lest the post-defense period would find much excess capacity, involving a huge capital investment, the fixed charges on which he estimated at around 75 million dollars annually. This is likely to represent a serious financial problem for management, faced with curtailed load and income, high taxes and low rates.

Addressing the Conference informally, **C. W. Kellogg,** Chief Consultant of the Power Unit, Office of Production Management, also quoted figures indicating that defense demands for power would be adequately met by the large amount of new capacity now under construction or ordered for completion by the end of 1942; this, despite earlier misgivings expressed by reports of the Federal Power Commission whose estimates necessarily must be revised from time to time as new capacity is ordered and as the defense demands change.

R. B. McWhorter, Chief Engineer of the Federal Power Commission, stated that, due largely to impetus of the national defense program, production of electric energy in the United States during the first three months of 1941 had been 12.5 per cent greater than that during the corresponding period of 1940. Much of the hydro power from Niagara Falls and the Massena plant in northern New York State, the TVA plants in the Tennessee Valley, and from the Bonneville development on the Columbia River is now being or shortly will be used in the manufacture of aluminum.

Reviewing federal hydroelectric developments now under construction Mr. McWhorter cited the Watts Bar and Fort Loudoun projects on the Tennessee River and the Cherokee project on the Holston River, with an aggregate initial capacity of over 200,000 kw; additional generating units of 236,000 kw capacity at the Wheeler, Wilson and Pickwick plants of the TVA; the Grand Coulee development on the Columbia River in the Northwest which is laid out for eighteen 105,000-kw units, the first of which will be ready by August 1941, the second in November and the third next March; and the Bonneville development in which two 54,000-kw units have lately been put in service in addition to the original 86,400 kw, and a fifth and sixth unit of like capacity are on order. The total contemplated capacity of this project is 518,000 kw.

The Santee-Cooper project in South Carolina, being constructed by a State agency will be completed by January 1, 1942, with an initial capacity of 130,000 kw and the Shasta project under development by the Bureau of Reclamation on the Sacramento River will provide 375,000 kw by 1944. The Bureau of Reclamation is also installing three additional 82,500-kw units at Boulder Dam and at the Parker Dam four 30,000-kw units, the first of which will be ready next December.

Among the private developments under construction are the Nantahala and Glenville projects in North Carolina which will have a combined capacity of 64,000 kw and the Cresta and Pulga projects of the Pacific Gas &

Electric Company which will have 68,000 kw and 80,000 kw, respectively, by 1943.

Other large federal developments are now under consideration in addition to the proposed St. Lawrence development.

Referring specifically to the production of aluminum, Mr. McWhorter stated that approximately ten kilowatt-hours of electric energy is required for the production of a pound of aluminum, the rate of annual output of which is expected to exceed 690,000,000 lb by July 1941 and 825,000,000 lb by July 1942. On this basis within the next 18 months the aluminum industry will be consuming energy at the rate of over eight billion kilowatt-hours annually.

According to Mr. McWhorter's figures, about 4,400,000 kw in steam electric plants and nearly 2,000,000 kw in hydroelectric plants are under construction or definitely planned for immediate construction. This estimate, however, was somewhat exceeded by other speakers whose source of information was apparently authentic.

Another angle to the subject of defense power was noted by **W. J. McLachlan,** of the General Electric Company, in a paper on "Trends in Equipment Design in Relation to Economics and Defense," who discussed the trend toward factory assembly of switching and substation equipment. Aside from the economic factors involved, this has great advantage under the present demands upon the electrical industry.

The country having gone through a period of several years during which virtually no substations were built, the considerable force of engineers who devoted their energies before 1930 to the design and construction of substations have long since turned to other fields of endeavor. Inasmuch as some major defense plants require up to 25 substations per plant, were it not for this factory assembly, the country would today be faced with a serious bottleneck due to lack of men experienced in the design and construction of substations.

Increasing Steam Output

Prof. R. S. Hawley, of the University of Michigan, in a paper on "Increasing Power Production with Present Boiler Facilities," drew an analogy between the production of manufactured articles and that of steam. With respect to the former, management is accustomed to pay close attention to the use of raw materials and to analyze factory methods and conversion costs. As to the latter, fuel, air and water are the raw materials and their use deserves equal attention.

Any attempt to improve boiler plant efficiency and increased capacity necessarily begins with the selection and purchase of fuel. Changing from a low-grade to a higher grade coal is one method of increasing output, generally without increasing the burning rate per square foot of grate surface. Another factor is the uniformity of coal mixtures and the prevention of segregation in storage in the bunker or on the stoker. Although coal may be sized and proportioned at the mine for proper mixture, it must not be assumed that this mixture will remain uniform until it reaches the stoker hopper, for handling of coal results in segregation of fines and the coarse material unless precautionary measures are taken. Furthermore, coal to be burned in pulverized form must be as carefully selected as to size and moisture content as that for stoker firing. Attempts to pulverize slack coal in a hammer mill will usually result in loss of pulverizer capacity and the presence of a small amount of clay will reduce the capacity of a ball or roller mill, especially if the coal is wet.

Increased efficiency and capacity will usually result from the addition of water-wall surface for either stoker or pulverized fuel firing. If this is not feasible, coal having a high ash-fusion temperature should be selected.

Since the output of a boiler is directly dependent upon the amount of coal burned and since the quantity of coal burned per unit of time is determined by the capacity of the fans or the chimney, it follows that any reduction in air quantity to that required for good combustion not only improves efficiency but also makes it possible to burn additional fuel and thereby increase the output. To this end the intelligent use of instrument charts should be encouraged by the management.

Among other points urged by the author were proper attention to soot blowing and the maintenance of the blowing elements; competent feedwater conditioning to avoid loss of capacity through the formation of scale on heating surfaces or foaming and priming with all their attending ill effects; the proper maintenance of traps to avoid waste of steam and condensate; and the balancing and scheduling of steam demand by various manufacturing departments, particularly the use of live steam where exhaust steam will suffice.

Instruments and controls, as a means toward increasing boiler output were discussed in a paper by **Charles W. Parsons** of Republic Flow Meters Company. "Modern boilers and auxiliaries deserve and require more than rule-of-thumb operation," he said, and "boiler room instruments and the tabulation of the measured quantities accomplish the same results as the inventories of raw and finished products and the time sheets in each department of every industry." Operations in the boiler plant involve uses of fuel, water, steam and power, and these quantities can be slightly or substantially reduced by giving the operator exact information as to the amounts being used and produced.

The first thing is to know whether the fuel-air mixture is correct. Boiler meters for this purpose are of two classes, namely, the direct-analysis type which provides information in terms of CO_2 in the exit gas, and the indirect method, or steam flow–air flow meter.

While the steam-flow meter may not point out as large possible savings as will a combustion meter, it is indispensable in that it provides a continuous indication to the operator, plus a permanent record, of the quantity of steam generated at all times.

Draft indicators are an important and useful guide to boiler operation and enable the operator to note at all times the draft available and the draft losses through the several parts of the boiler, fans and air heater. Reduction in fan output, leaks in baffles and slagging of gas passes can be quickly detected by an alert operator watching the draft indicators.

Temperature recorders serve to flash danger signals of conditions that may jeopardize continuous operation.

The author cautioned, however, that despite the increase in boiler output and substantial savings possible through the use of meters, they will avail little if no attention is paid to their indications and readings.

Automatic combustion control he regarded as essential in operating large modern boilers and it is also finding increasing application on relatively small boilers, for which service dependable controls have been developed at a cost that makes them a profitable investment in these smaller plants.

Power Trends

In presenting a résumé of present-day power trends, **Prof. A. G. Christie,** of Johns Hopkins University, linked these with the influence of recent economic and political events. These included the continued increase in domestic load during the last decade, the pick-up in industrial load starting in 1937 and later stimulated by war demands, the huge hydro projects initiated by the Government and its campaign for rural electrification. From a military point of view these large hydro plants he regarded as vulnerable, while long distance transmission lines are subject to interruptions which emphasize the necessity of steam standby service in the communities served.

Although very large steam stations will continue to be built, as in the past, they involve many large feeders radiating from a single point and are also excellent military targets. In view of these considerations, the author believed it possible that there may be a future trend toward more scattered stations of moderate size; for, as he pointed out, the practice of unit construction of one boiler and one turbine permits the design of smaller plants with efficiencies practically equal to those of the super power plant.

A marked trend in recent years has been toward the employment of bent-tube steam generating units with definite circulation paths from and to the drums, which appear to have overcome the recirculation difficulties experienced in certain earlier straight-tube types. There is considerable basis for the expectation that metals will be developed suitable for 1200 F steam temperature in which case initial pressures of 2000 to 2500 lb per sq in. may be employed on the regenerative cycle without excessive moisture at the exhaust.

As to steam turbines, Professor Christie envisioned more extensive use of 3600-rpm units. They are of less weight and, with smaller physical dimensions, are less affected by temperature changes than 1800-rpm units. Such condensing units are more economical than 1800-rpm machines in sizes below 50,000 kw, although there is little thermal advantage in 3600-rpm condensing units above 50,000 kw.

Steam Turbine Design

C. C. Franck, of Westinghouse, reviewed the advances in steam conditions, turbine sizes and improvements in performance from 1900 to the present time, a sharp reduction in heat consumption occurring around 1922 with the adoption of the regenerative cycle. Widespread use of industrial turbines of from 1000 to 7500 kw firmly entrenched the 3600-rpm type of unit with subsequent decrease in physical size, although up to 1928 units of 10,000 kw and above were confined to the 1800-rpm class.

While thermal studies indicated further operating economies by increase of pressure and temperature, materials then available limited the upper temperature and it was possible only to utilize the increase in pressure. Hence, the earlier 1200-lb, 750-F units experienced excessive moisture and erosion of the exhaust blading, to combat which interstage reheating was adopted with its accompanying complications in boiler and plant layout. However, the turbines used in conjunction with the high-pressure sections of these plants were the forerunners of the modern superposed turbines. These units were of 10,000 to 12,500 kw and 3600 rpm.

Metallurgical developments made possible the use of 925 to 950 F total steam temperature around 1934 to 1936 and many superposed plants resulted. The installation of new condensing capacity for the greater part developed around steam conditions of 850 lb per sq in. and 900 F, although in some cases 1250 lb and 900 to 925 F has been justified. Practically all this development centered around 3600-rpm units. Superposed units and tandem condensing units of 65,000 kw are under construction and, by various combinations of cylinders, units of 100,000 kw at 3600 rpm are under construction or in operation.

Higher temperatures have dictated the use of solid forgings for turbine rotors, regardless of the type of turbine employed. Also, higher temperatures and stresses in rotating parts have necessitated use of alloy-steel forgings and although difficulties have been encountered, the problems associated with this type of forging have been taken into account by maintaining control over the homogeneity of the material and adequate stress-relieving.

The majority of the design problems of the turbine engineer center about the ability to predict and allow for the effects of differential temperature. For example, a 50,000-kw, 3600-rpm turbine operating at 850-lb, 900-F and 29-in. vacuum has an overall change in length of $^3/_4$ in. when passing through its normal heating and cooling cycle. Also, the expansion of the main steam line transmits reactions to the turbine cylinder. As the mathematical solution to this piping stress problem is laborious, it is customary to study the effects by means of scale models to determine the resultant forces.

When the newly designed machines of the 1935–1937 period were placed in operation, difficulty was encountered with rusting of the lubricating systems and associated parts. This was not red rust but black magnetic oxide of iron in hard blister form with corrosion pits underneath. Investigation disclosed that the cause could be traced to the highly refined turbine oils which had removed a desirable element in the older oils that "wetted" the surface, and when small traces of moisture were present the phenomena proceeded at a rapid rate. This discovery resulted in development of the "Kuebler Test" for determining the rusting propensity of oil. It is interesting to note that the early rusting problems were cured by "vaccinating" the new batch of highly refined oil with the addition of a small percentage of old oil, which established the necessary wetting properties.

Forced Circulation

In an informal presentation with slides, **F. H. Rosencrants,** Vice President of Combustion Engineering Company, Inc., discussed forced circulation with particular reference to the large high-pressure boiler now under construction for the Somerset (Mass.) Generating Station of the Montaup Electric Company, which will be the first installation of this type to be made on a large commercial scale in this country. He pointed

out that the scheme of forced circulation as here applied is essentially no different from that of natural circulation, except that the hydraulic head normally available for natural circulation is augmented by the installation of a circulating pump, or pumps, connected between the downcomer pipe from the upper drum and the headers at the bottom of the furnace. Although the steam pressure will be approximately 2000 lb, the circulating pumps operate at low differential head.

Besides augmenting the head for circulation the Montaup design involves control of the distribution of water to the various circuits by means of orifices inserted at the entrance to the individual tubes where they connect to the lower header system. The flow of steam-free water at this point makes the calculation of orifice dimensions approach an exact science in contrast to the uncertainties introduced by a mixture of steam and water of unknown proportions, were similar restrictions to be placed at any other point in the circuit. The definite drop in pressure imposed by the orifices results in a predetermined distribution of the total water flow.

The total flow of water handled by the circulating pumps is substantially in excess, in pounds per hour, of the steam production rate of the unit—sufficient to insure wetted surfaces at all points where gas contacts these tubes. Furthermore, by this means, turbulent flow is insured at all points and particularly so in the hot zones of the furnace. To this end, small diameter tubes are essential as tube diameters such as normally used in natural circulation boilers would require a prohibitive volume of circulation to bring about the turbulent flow characteristics desired. Such turbulence is particularly desirable to avoid scale deposits, pitting, etc., as associated with non-turbulent flow which permits steam films in contact with the inner surfaces of the tubes.

In natural-circulation boilers circulation is dependent upon the varying densities of the water and the water-steam mixtures at different temperatures, and for high pressures this involves placing the drums at a considerable height in order to provide the necessary hydraulic head to assure circulation. On the other hand, forced circulation, as described, insures positive circulation, independent of the load and permits flexibility in the arrangement of heating surfaces to meet space requirements and allows the steam drum to be placed in any convenient location.

In the case of the Montaup unit there will be three circulating pumps, as distinct from the feed pumps. One will be motor-driven and the other two will have dual drive. Any two of these will provide circulation for maximum load conditions.

The unit, which is designed for 650,000 lb of steam per hour at 2000 lb pressure, will operate at 1825 lb, 960 F at the superheater outlet and will employ a tangentially-fired furnace having a continuous slagging bottom. It will be equipped to burn oil as an alternate fuel to the pulverized coal supplied from the existing storage system. Included are a convection type superheater, reheater, economizers and regenerative-type air preheater. Steam will be furnished to a 25,000-kw topping turbine exhausting to the existing low-pressure turbines at 375 lb.

What the User Should Know

At a luncheon meeting **Alfred Iddles,** of Babcock & Wilcox Company, spoke on "The User Wants to Know." His remarks were in substance as follows:

In writing specifications for a steam-generating unit, there is a great deal more needed by the manufacturer than the plain statement of pounds of steam required per hour, together with the pressure and temperature. The most important variable probably is fuel, and to specify that the unit shall operate with equal ease with natural gas, oil or coal, is to ask for the impossible. The heat-absorbing characteristics are materially different for these different fuels and if uniform steam temperature is required for the same variation in load, then a very flexible and more costly unit must be designed.

Also, to specify feedwater temperature at normal full load is insufficient, as feedwater temperature at the lower loads has a large effect upon superheat temperature. Likewise, accidental reduction in feed temperature due to heater failures has a tremendous effect upon the resulting superheat and the amount of fuel to be burned. A reduction from 450 to 350 F will amount to as much as 45 deg in superheat for the same steam output and means an increase of ten per cent in the heat input. Such a change will materially affect the temperatures throughout the unit and may affect the ash and slag conditions. Therefore, it would be best to state clearly what the expected normal operating conditions are and then ask for estimated results in case of departure from these standard conditions.

Higher steam temperatures have resulted in units more sensitive to changing conditions in the furnace.

The accuracy with which hand or automatic combustion control maintains good combustion and constant excess air will materially affect superheater performance. In the 900 to 1000 F range, the turbine manufacturer wishes accurate temperature control and recently has asked for limitations in the range of temperature and also in the rate of change. So far, it has been impossible to maintain these severely constant conditions and at the same time permit of the rapid and wide swings in steam output which some systems require.

Whether the increase in efficiency due to high superheat is warranted in view of the possible damage to the turbines or whether it justifies the extra cost of automatic control to meet the swinging load, may well be questioned. Certainly no automatic device can be expected to foresee the extent and direction of major swings in load, and if steam temperatures are to be maintained within a narrow range, the intelligence of supplemental hand control will undoubtedly be required.

The willingness of owners to purchase equipment which departs in some measure from exact past practice has often carried with it the need for patience in starting up and testing the equipment. Many times outages and loss of use occur while changes or adjustments are made. Not only has it been necessary to do this research on full-sized units in the field, accompanied by loss of use, but such procedure has also meant considerable expenditure on the part of the manufacturers first to determine the cause of the troubles and then make changes to overcome them. The money spent in laboratory work to enable these new high-temperature designs to be constructed, has been large. The industry profits by these activities but in addition to paying for research in the plant, must in the long run also pay for the cost incurred by the manufacturer in carrying on this rapid development work.

Some owners seem willing to purchase oversized equip-

ment or to operate at the easiest load for the equipment after its characteristics have been determined; whereas others expect to obtain considerable overload and if the specifications do not clearly set forth the viewpoint of the owner, the manufacturer is at a loss to know how to design.

Neither the equipment nor its designer can control the characteristics of the coal or other fuel that is supplied. Some of our worst recent troubles have been with slag resulting from the use of fuel oil. No designer can control the maintenance of equipment that is likely to determine the fineness of coal from the pulverizer, nor can he regulate conditions. If the owner expects to run the units at an exceedingly high load factor and at full load or overload, then he should know whether this procedure was contemplated when the equipment was designed.

Finally, the owner should want to know whether he has supplied his organization with sufficiently trained personnel, for a crew accustomed to 700 F steam may not realize the limitations surrounding operation at 900 to 950 F.

Water-Treatment Problems

Prof. F. G. Straub, University of Illinois, reviewed broadly the various water-treatment problems in the steam power plant and how they are met. Classifying these under four general headings of scale, corrosion, embrittlement and carryover, he stated that in the higher pressure, higher temperature plants it is necessary to remove as much as possible of the scale-forming material from the feedwater before it enters the boiler. Such pretreatment may involve the hot process, cold process, zeolite, Zeo-Karb, demineralization or evaporators, or a combination of several methods. With the major portion of the scale-forming materials thus removed it often then becomes necessary to add small amounts of phosphates, colloids or organic extracts. Care should be taken that the final treatment does not cause a dangerous type of sludge formation that will bake on the heating surfaces in areas of sluggish circulation.

In lower pressure plants, up to 250 lb, it is often possible to operate boilers with 30 to 40 per cent makeup with internal treatment. In such cases it is seldom possible to treat with the theoretical amounts of inorganic chemicals such as phosphates, soda ash, etc., as the resulting soluble solids are likely to build up and cause carryover. It is preferable to use small amounts of colloids, organic extracts, etc. However, blowdown should be suitably arranged with any internal treatment.

Corrosion usually results from the presence of oxygen although occasionally it may be traced to acid water. Mechanical removal of oxygen is highly desirable, but it is essential that the deaerating heaters and their vents be checked at regular intervals. In many plants it is advisable also to treat with chemicals to remove the last traces of oxygen. If the feedwater has a pH above 8.5 it should not be corrosive.

Many plants encounter corrosion in steam-heating return systems, particularly when the return pipes are only partially filled with water. This occurs when the carbon dioxide content of the steam becomes appreciable. The CO_2 tends to form carbonic acid which produces acid condensate. The remedy may involve removal of the CO_2 (which is rather difficult), neutralization of the acidity or a change in the piping so as to keep it well drained or completely filled with condensate. Corrosion in the absence of oxygen has also been encountered in high-pressure boilers where certain tubes are steam blanketed or partially dry.

As to embrittlement, the author stated that no cases of such action in stationary boilers had been reported where the A.S.M.E. sulphate-alkalinity ratios had been maintained. However, with the improved fabrication of boilers having welded drums embrittlement has become almost impossible in modern units.

In the larger plants continuous records are kept of the steam conductivity in order to indicate carryover, but it is necessary that the sample be free from or corrected for the presence of gases such as CO_2 or NH_3; temperature corrections must also be made. On the other hand, in smaller plants a continuous sample of the condensed steam flowing through a bottle may suffice to give visible indications of surges of carryover. In order to protect turbine blading from deposits it is necessary that carryover be low. Often a proper balancing of chemicals within a boiler will give a nonadherent carryover that will not cause blade deposits.

Removal of Dissolved Gases

A lengthy paper by **A. E. Kittridge,** Chief Engineer of Cochrane Corporation, dealt with recent developments in the removal of dissolved gases from boiler feedwater to meet the present stringent requirements for lower residual gas content and the removal of carbon dioxide and ammonia, as well as oxygen. Reviewing the fundamental principles concerned, the author showed that the process involves two phases of gas removal, the extent of the first phase being controlled primarily by the surface tension of the liquid and the pressure to which the system is subjected, and the extent of the second phase being controlled by the individual tray efficiency, the number of layers of trays and the viscosity of the water as fixed by the temperature of operation. It was pointed out that carbon dioxide and ammonia not only do not follow the same law as oxygen but differ from one another.

The four characteristically different pieces of equipment commonly used to remove dissolved gases from boiler feedwater are aeration tanks, decarbonators or packed wooden towers, tray deaerators and jet-atomizing deaerators. Aeration tanks, which may consist of bitumastic-lined steel tanks having several vertical passes in which are located compressed air diffusers, have been employed satisfactorily for removal of carbon dioxide following zeolite treatment. However, they seem to be limited to low-capacity equipment. The packed wooden-tray tower degasifier, or decarbonator, is the dominant method of removing carbon dioxide from boiler feedwater with atmospheric air, whereas the tray-type deaerator has the broadest application in the field of oxygen removal from feedwater. The jet-atomizing type was developed to serve those water supplies which would corrode standard deaerating trays and it has found wide application in the marine field, as well as use in stationary plants.

High tray stacks are more logical than shallow tray stacks because, pound for pound, they are more efficient than shallow tray stacks.

In so far as the removal of oxygen is concerned, the

direction of steam flow through or across the tray stack is inconsequential except as it may adversely affect the distribution of water on the stack. In spray or atomizing deaerators means should be provided for maintaining a constant pressure drop across the atomizing valve.

The complete removal of carbon dioxide or ammonia from a water supply otherwise neutral becomes difficult due to the high degree of ionization of small quantities of these gases in solution. Complete removal of these gases is only practically possible at the present time by the use of another acid or base, to drive the ionized fractions of the respective gases into a form that is removable.

Since an absolute zero oxygen is not a logical term as applied to the removal of dissolved gases from boiler feedwater by a physical process, it was suggested that oxygen guarantee values be set at the lowest finite values that can be considered within the limits of reliable determination.

Interchange Contracts Between Industrial Plants and Utilities

A paper on this subject by **John T. Davis** of the Indianapolis Power and Light Company, presented in the author's absence by P. W. Ross of that company, explained how such relationships between the power company and various industrial concerns in Indianapolis had worked out to the mutual economic and operating satisfaction of both parties to the contract. An annual revenue of over $800,000 is derived from the sale of both high-pressure steam and electricity to eleven large industrial plants, four of which generate a part of their own electrical requirements.

The first such contract was negotiated with the Eli Lilly Company in 1931 which was then confronted with the possibility of spending $500,000 for a new power plant, but as a result of the interchange arrangement the customer spent $100,000 and the power company $150,000, thus effecting a combined investment saving of $250,000. By the terms of the contract the power company supplies steam through a mile line to the customer's turbine at 175 lb and 100 deg superheat at an anticipated rate of 60,000 lb per hr. At such times as the power generated by the customer exceeds his requirements the power company agrees to absorb the excess, whereas during periods when the customer's electrical requirements exceed that generated by his own turbine-generator the deficiency is drawn from the power company's system. If the customer receives more kilowatt-hours from the power company than he delivers during the month he is billed for the difference at 1.35 cents per kwhr; whereas if the reverse holds the power company pays $^1/_4$ cent per kwhr received.

Incidentally, the customer's electric demand has grown so that there has been no back feed since 1936 and the power company's electric revenue in this case has risen from $24,138 in 1932 to $62,745 in 1940 and the total revenue to the power company over the nine years has amounted to more than a million dollars.

Among the other customers operating under similar or modified arrangements are the E. C. Adkins Company, saw manufacturer, which utilizes the steam through an 80-hp engine during the heating season and which takes annually 80 million pounds of steam and approximately $2^1/_4$ million kilowatt-hours; Kingan & Co., large meat packers; a paper mill; a brewery; two large hotels; a laundry; and a Federal Housing Project.

In the case of Kingan & Co. steam is supplied at 225 lb, 150 deg superheat to a 2500-kva noncondensing double-extraction turbine-generator. Steam is billed on the utility's industrial steam rate at an average of 32 cents per thousand pounds, and for each kilowatt-hour generated by the customer he receives a credit of 16 lb of steam at the average rate earned for that month. The customer is billed for the kilowatt demand created on the company's distribution in addition to the kilowatt-hours generated by the turbine. The utility furnished and installed the turbine-generator at a cost of $75,000, the customer agreeing to pay 12 per cent fixed charges on this part of the investment until such time as he may elect to purchase the equipment at its then depreciated value. The investment on the customer's premises to adapt his plant to this method of operation amounted to approximately $125,000.

Variable-Speed Drives

G. V. Edmonson, of American Blower Corporation, discussed some of the more important considerations in the application of variable-speed drive to power-plant auxiliaries. Such drives include steam turbines, multi-speed motors, dual motor drives, direct-current motors, wound-rotor and brush-shifting alternating-current motors, hydraulic and electric couplings, variable-pitch pulley arrangements, and the positive-displacement oil motor. His paper, after reviewing briefly the application of these various drives to meet specific conditions, proceeded to discuss the hydraulic coupling in detail. Two designs, namely, the "pump controlled" and the "scoop controlled" couplings were shown and described.

It was explained that since the hydraulic coupling consists of only two rotating members, the torque output for all conditions of speed and filling is equal to the torque input and it follows that the efficiency is the per cent speed; that is, the efficiency at 75 per cent speed is 75 per cent and at 50 per cent speed the efficiency is 50 per cent. To this loss must be added the pumping and windage loss.

Priorities in Men

The speaker at the Conference Dinner was **Dr. Harvey N. Davis,** President of Stevens Institute of Technology, whose address, entitled "Priorities of Men," stressed the present marked shortage in technically trained men for the defense industries. Inasmuch as production, at our present stage of defense activity, is more important than combat training, he proposed that draft boards give careful consideration to deferment of those engineers who could be of greater service in defense industries—in other words, that these needs be given priority over combat training.

Other papers at the Conference were "Operation of the Multi-purpose Projects of the Tennessee Valley Authority," by **S. M. Woodward;** "Construction of the 48,000-Hp Kaplan Turbines for the Pickwick Landing Dam of the TVA," by **W. J. Rheingans;** and "The Limitations Placed on Power Transmission by System Stability," by **H. E. Wulfling.**

Controlling Characteristics of Ash

WITH SPECIAL REFERENCE TO ILLINOIS AND INDIANA COALS

JOSEPH HARRINGTON

Advisory Engineer

THE softening (or fusion) temperature of coal ash is playing an important part in both the selling and buying of coal; also in the classification of coal.[1] The determination of the temperature at which the ash in coal fuses has been of use for almost twenty years in a commercial way. In order to clear up the uncertainty regarding this feature of coal testing, the United States Bureau of Mines and the American Society for Testing Materials, referring to the well-known cone test, have defined it as follows: "The *softening temperature* is that at which the cone has fused down to a spherical lump."

Critical points other than the softening temperature that may be observed during the cone test, and which may be of value, are *the initial deformation temperature* which is defined as "the temperature at which the first rounding or bending of the apex of the cone takes place, such bending not to be confused with a shrinking or warping of the cone"; and *the fluid temperature* which is "the temperature at which the cone has spread out over the base in a flat layer."

Investigations covering a large number of these coals have demonstrated that the acid-base ratios of the ash offers a reliable index to the fusion temperatures, and means were developed to control the ash characteristics by the addition of silica or lime to secure the desired results. Approximately 2000 tons of coal per day are being treated with silica. It was further demonstrated that the controlling influence in the production of objectionable clinkers is not the softening point of the ash but the point of fluidity or the spread between the softening and fluid temperatures.

A *clinker* is literally a fused or a partially fused mass of the incombustible refuse resulting from the burning of coal. It is derived from the word "clink," the sound that the vitrified material makes when struck or thrown against a metallic surface. In the practice of firing a furnace, however, the word has come to have a more specific meaning—one which conveys a whole list of undesirable qualities. A fireman makes no complaint if the ash in his furnace vitrifies to a multitude of glassy nodules or to brittle flakes easily removed from the fire. It is only when the ash fuses into unwieldy masses, attaches itself to the grate bars or adheres solidly to the brick walls of the furnace that he voices unreserved condemnation of the coal. The term, therefore, has come to be one of opprobrium, implying the most undesirable characteristics.

Initiation of Investigation

Reports from field men constantly noted the fact that coal from a certain mine did not produce destructive clinkers. Yet analyses showed that the ash from this coal fused at a much lower temperature than that from others which were viciously destructive. This was, to say the least, confusing in view of the accepted idea that low fusion and clinkers went together.

The need for research in this field was imperatively indicated by continued failures of another coal to perform in the orthodox manner, even though the softening point of the ash appeared satisfactory. Instead, this coal formed a vicious slag that froze to the grate bars, cut off combustion air and burned the grates to such an extent that total destruction occurred in a few weeks or in some cases in a few days. None of the usual changes in operation of the stoker or furnace made the slightest difference, and it became necessary to discard all these and resort to a far more basic analysis.

No item in the proximate analysis is without its significance, but it is the fusibility of the ash that carries the greatest weight. In fact, while the other items may vary widely without materially impairing the usefulness of a coal, a relatively slight difference in the ash fusion temperature may make a coal utterly unusable. This is because the fusion of an ash involves a train of events not associated at all with moisture, volatile or fixed carbon. These elements simply pass off as gases in greater or lesser amounts without having a disturbing influence beyond slightly affecting efficiency, rate of combustion or the like.

The residue left after burning off the combustibles is a solid which must be removed from the fire continuously or at frequent intervals in order to maintain the fuel bed in effective condition and preclude the certainty of fouling the fire, clogging the air passages and possibly of causing the actual physical destruction of the grate itself.

The basic idea governing previous research on the effect of adding substances to coal to affect the character of ash has revolved around the softening point as the determinative item. As stated before, the author early noted the apparent inconsistency of low fusion and satisfactory furnace performance. To explore this field, he determined first to develop the relationship between the softening point of the ash and its acid-base ratio. Fortunately, quite a large number of complete analyses were available.

[1] Statement from a bulletin of the Commercial Testing & Engineering Company.

Acid-Base Ratio

In these calculations the sum of the silica and alumina was taken as the acidic, and that of the iron and lime as the basic. It is true that there are other substances in the ash, but they are usually small and the ratio is not materially affected by their inclusion. For reasons of simplification, therefore, they were omitted.

During January 1938 and succeeding months, chemical analyses and fusion tests were made of various coals. The acid-base ratios were calculated and a definite relationship established between this ratio and the softening point; see Fig. 1. One complete analysis is included for illustration:

	Per cent
SiO_2 (silica)	28.92
Fe_2O_3 (iron oxide)	45.22
Al_2O_3 (alumina)	14.78
CaO (lime)	5.32
MgO (magnesia)	0.56
Na_2O and K_2O (alkalies)	2.26
SO_3 (sulphur trioxide)	2.76
P_2O_5 (phosphorous pentoxide)	0.18
	100.00
Fusions	
Initial	1873 F
Softening	1960 F
Fluid	2004 F
Acid-base ratio	
Silica plus alumina (*a*)	43.70
Iron plus lime (*b*)	50.54
Ratio *a*/*b*	0.86
Percentage acidic	
Silica plus alumina (*c*)	43.70
Sum of basic and acidic (*d*)	94.24
Ratio *c*/*d*	0.47

The curve of Fig. 1 was thus developed. It is a curve of definite character, each dot thereon representing a complete analysis similar to the one shown above. Different coals are indicated by a difference in the shape of the dot. The group at the upper left, to the left of acidic percentage 30 and above 2100 F fusion temperature, had the most vicious clinker possible.

The final result of this work was to establish beyond question the fact that an increase in the acid-base ratio affected the softening point of the ash on the following general basis:

1. If the acid-base ratio in the natural coal was less than unity (corresponding to 50 per cent acidic), an increase effected by raising the amount of acidic material *lowered* the softening point.
2. If this ratio was more than unity, an increase *raised* the softening point.

The coal first examined contained a superabundance of the basic substances, lime and iron, so that it becomes obvious that small increments of silica (acidic) actually make the coal more likely to fuse. In confirmation of this the results of one typical test showed:

		Silica Increments				
	Untreated	1%	2%	3%	4%	5%
Initial	1807 F	1807 F	1794 F	1820 F	1807 F	1820 F
Difference, deg.	129	79	79	91	104	103
Softening	1936 F	1886 F	1873 F	1911 F	1911 F	1923 F
Difference, deg.	46	37	112	206	518	730
Fluid	1982 F	1923 F	1982 F	2117 F	2492 F	2653 F

To make these figures even clearer, Fig. 2 was drawn. The close grouping of the softening temperatures, with all increments of silica, makes it apparent that the decisive reactions between the silica and the ash do not take place until a temperature *in excess of the softening temperature* is reached. It is equally certain that the reactions between the ash and the silica of the bricks in the side walls or the iron of the grate bars do not take place until a similar temperature is reached. As the

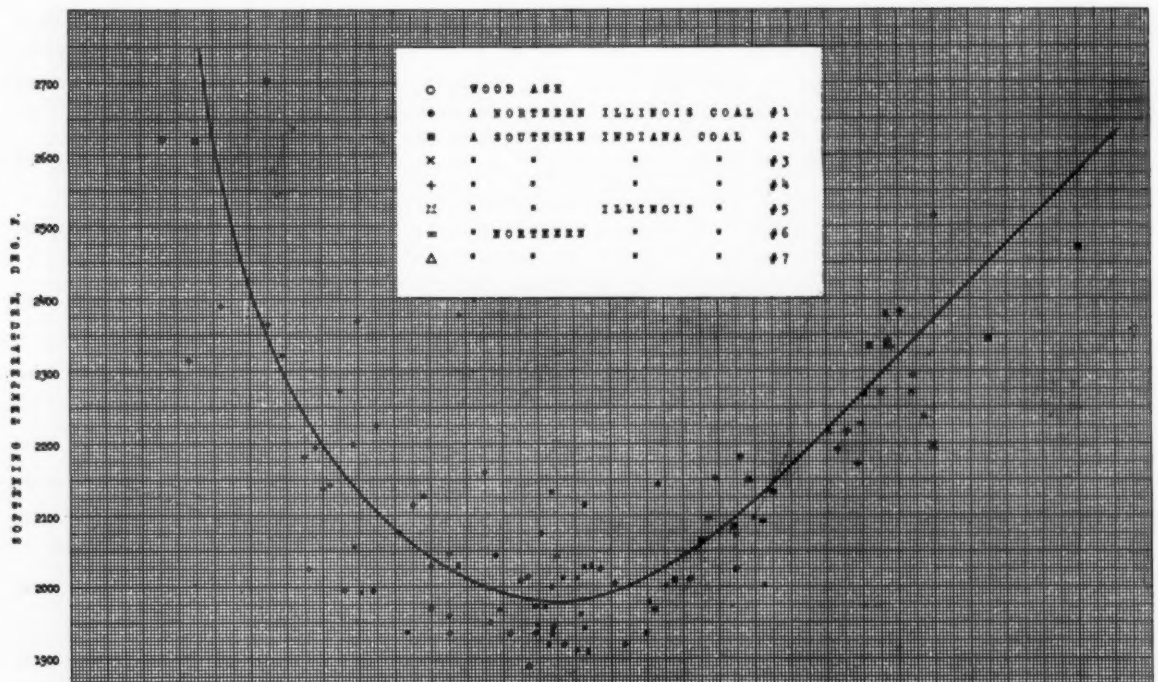


Fig. 1—Acid-base ratio plotted against softening temperature for a number of coals

typical bad clinker can originate only in ash fluidity, it is apparent that the standard practice of judging the performance of this coal by the softening temperature of the ash is definitely wrong, and consequently misleading.

In order to find out what was the determining factor, the research was extended to include the fluid temperature of the ash. Only when this figure was determined did the results check with observed performance.

Fig. 3 is added to emphasize the fundamental principles involved. It shows the widening spread between

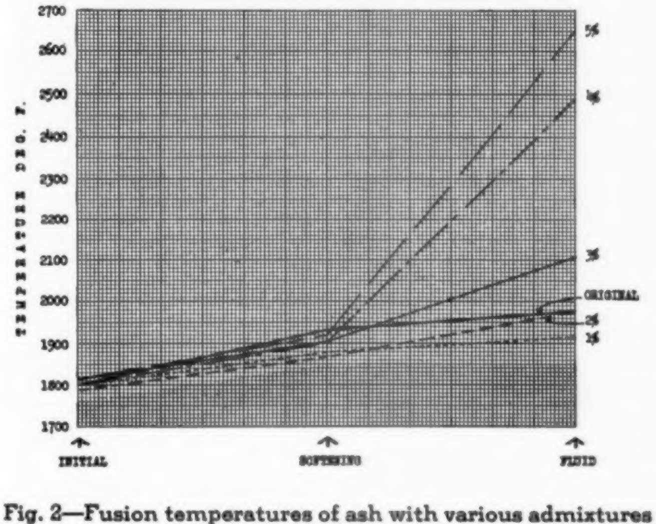


Fig. 2—Fusion temperatures of ash with various admixtures of silica

the softening and the fluid temperatures as increased percentages of silica are added. It is practically impossible, under any ordinary furnace conditions, to get a clinker of any kind with coal treated with four or five per cent of silica, despite the fact that the softening point is actually lower when thus treated.

There must be something other than the softening temperature of the ash that is involved in the furnace behavior of this coal. To explore this further, a different sample was secured. This had the following fusion characteristics:

Initial	1930 F
Softening	2025 F
Fluid	2200 F

Four, five and six per cent of silica were successively added with the following results:

	Silica Added		
	4%	5%	6%
Initial	1950	1980	2400
Softening	2040	2060	2510
Fluid	2420	2490	2615

The significance of these figures is best seen by plotting them in a simple graph, Fig. 4, from which is seen,

1. The slight influence on the initial and softening temperatures by the addition of either four or five per cent of silica.
2. The big jump in fluid temperature upon the addition of four per cent and the continued increases with the higher percentages.
3. The very high grouping of all the six per cent temperatures.
4. The constant difference, with all percentages, between the initial and softening temperatures.

Repeating the statement that it is almost impossible to get a fluid clinker with coals having the higher acidic percentages, such as illustrated in Fig. 4, it is enlightening to note the fusion differences with coals of the same approximate softening temperature at the two sides of the curve in Fig. 1. A typical coal in the left-hand group had the following fusions:

Untreated		Differences
Initial	1930 F	
Softening	2025 F	95 deg F
Fluid	2200 F	175 " "
Acidic percentage 30		

For ready comparison of differences the other analysis is repeated, using only the 4 per cent figures:

4% Silica		Differences
Initial	1950 F	
Softening	2040 F	90 deg F
Fluid	2420 F	380 " "
Acidic percentage 60		

Following the 2300-deg line of Fig. 1 to its intersection with the right-hand part of the curve, we note it cuts through another group. While the ash of the left-hand group was exceedingly destructive, it was almost impossible to get any kind of a clinker from this coal although the softening point of the ash is exactly the same as the left-hand group. The coals of the right-hand group belong to the class with high acidic ratio with the fluid

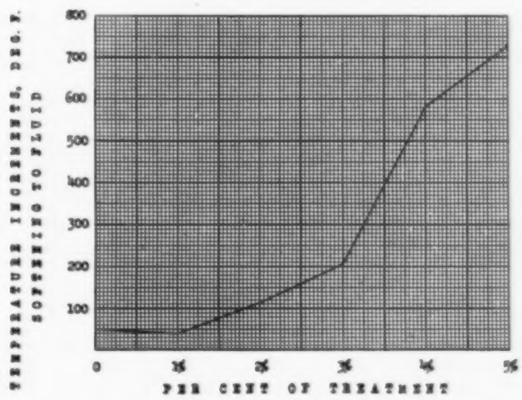


Fig. 3—Temperature increments, softening to fluid

temperature, as in the case just shown, as much as 380 deg above the softening temperature.

The practical application of this is apparent. In the former case, the difference between the beginning of fusion and a state of liquidity is so small that no sooner does the ash start to soften than it falls into a liquid state. Being in this condition nothing can prevent its instantly running down through the voids in the fuel bed to the grate surface, where it freezes to the grate bars, clogs up the air openings and makes a solid clinker.

In the other case, the ash may soften at the indicated temperature, but increasing temperature only makes it a little more soft but not liquid. In this state it gradually settles down into contact with adjacent particles like a popcorn ball. It cools in this condition and emerges a porous, spongy, light mass such as shown in the photo-

graph. This is an ideal clinker. From this the following simple and direct conclusion may be drawn:

The controlling influence in the production of objectionable clinkers is not the softening point of the ash but the point of fluidity or the spread between the softening and the fluid temperatures.

All of the foregoing has been on the basis of increasing the acid-base ratio, or the percentage of acidic material, and producing a more inert ash. If the percentage of acidic material is over 50, the effect is also to raise the softening point some and the fluid point a great deal.

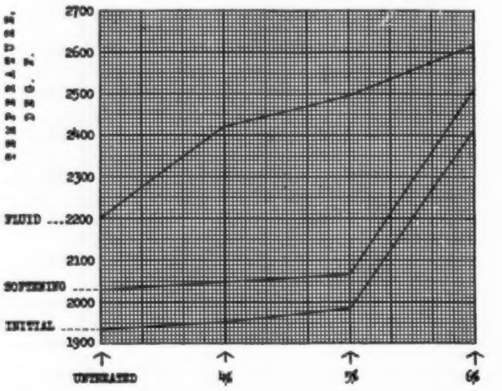


Fig. 4—Effect of silica treatment on fusion temperatures

With certain types of furnaces, such as the slag-tap pulverized-coal furnace, the desire is just the reverse, i.e., to lower the fluid temperature. To see if the acid-base ratio and the various fusions held good in the direction of lower ratios, a southern Indiana coal was selected and the fusions determined.

Then an admixture of calcium oxide (lime) to the extent of 2 per cent of the dry coal was added and the fusions again determined. The acid-base ratio was lowered, of course, and the fusions followed in regular order. These results are tabulated below and shown graphically in Fig. 5. They seem to be highly consistent.

	Mine location—point No. 1	No. 2
Untreated coal		
Initial	1970 F	1975 F
Softening	2165 F	2170 F
Fluid	2355 F	2370 F
Treated with 2% CaO		
Initial	1810 F	1865 F
Softening	2015 F	2030 F
Fluid	2210 F	2210 F

Discussion of Results

The author ventures into the realm of chemistry with some hesitation, but feels that some discussion of this phase is desirable.

The iron in this coal appears as the sulphide. When burned the sulphur is oxidized and either passes off as a gas or combines with other elements in the ash. We are not herein directly interested in this phase of the problem.

The iron is oxidized to one of three possible oxides, namely, ferrous oxide (FeO), ferric oxide (Fe_2O_3) or a combination of the two (Fe_3O_4). This usually is magnetic, a characteristic of this particular ash. When the higher oxide is heated in the presence of iron, the oxygen spreads over more iron to form a lower oxide, securing this from the grate bars. We call it burned grates, which it really is, chemically speaking.

The fusing point of coal ash is lower in a reducing atmosphere than in an oxidizing one. The Babcock & Wilcox Co. give interesting figures for an Illinois coal,[2] as follows:

Fusions	Atmosphere Reducing	Oxidizing
Initial	2020 F	2410 F
Softening	2110 F	2490 F
Fluid	2290 F	2510 F

Even though the ash is first burned to a high or ferric oxide, it may be reduced to the ferrous state in the upper part of the fire. By virtue of the lowered fusion point, it immediately liquefies and runs down to the grate surface or dead plate. Upon reaching this point it spreads out into a thin sheet, shutting off combustion air and causing the supporting grate bars or dead plate to absorb heat up to a high temperature. Not all of the ferric oxide is reduced. In all probability there is an admixture of the ferric and ferrous in a combination such as the magnetic form (Fe_3O_4). The magnetic nature of this slag lends color to this theory.

A chemical reaction is then in order between the ferric portion of the slag and the iron of the grate bar, and some of the iron is lost to the slag.

The melting point of pure FeO is about 2590 F, and that of Fe_2O_3 about 2840 F. While the author has seen

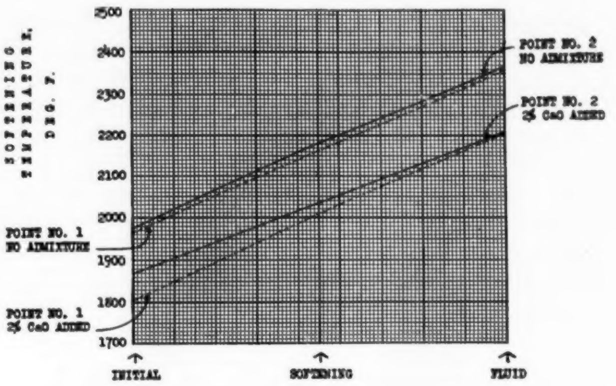


Fig. 5—Effect of lime treatment on fusion temperatures

fuel-bed temperatures of 2600 F, it is most probable that these figures are considerably above the ordinary. It is probable that we do not have these pure oxides to deal with, but some combination of iron with one or several of the other elements shown in the foregoing ash analysis. While the actual melting point may thus be affected, enough reactivity remains to produce the results actually encountered.

It will be seen that the burning of grate bars is primarily a strictly chemical reaction between the bar and the ash or slag. Very rarely is it the direct result of the bar being heated up to the combining point with the oxygen of the combustion air. Such cases are confined to the use of the very low-ash fuels, such as petroleum coke or the lowest ash bituminous coals.

[2] From an analysis made in connection with the operation of a slagging-bottom furnace in a midwestern utility plant.

As noted, the softening point of ash is of no value in predicting the performance of this coal. It is only when fluid temperatures are viewed that the case becomes clear. When silica is added to the coal it simply remains as inert material during the early combustion stages. As the ash gradually forms the silica mingles with the iron, ready for chemical action as soon as the fuel bed temperature reaches a degree that permits such action to take place. Then there is a combination of the silica and iron oxides as follows:

$$FeO + SiO_2 = FeSiO_3 \text{ (ferrous silicate)}$$
$$Fe_2O_3 + SiO_2 = Fe_2SiO_5 \text{ (ferric silicate)}$$

When these reactions are complete we have an entirely new and different substance, namely: a *ferro-silicate.* The old oxide that was so destructive is itself destroyed. The new substance is chemically satisfied and no longer has the power to abstract iron from the grates. In direct consequence, therefore, the power to burn the grates is gone.

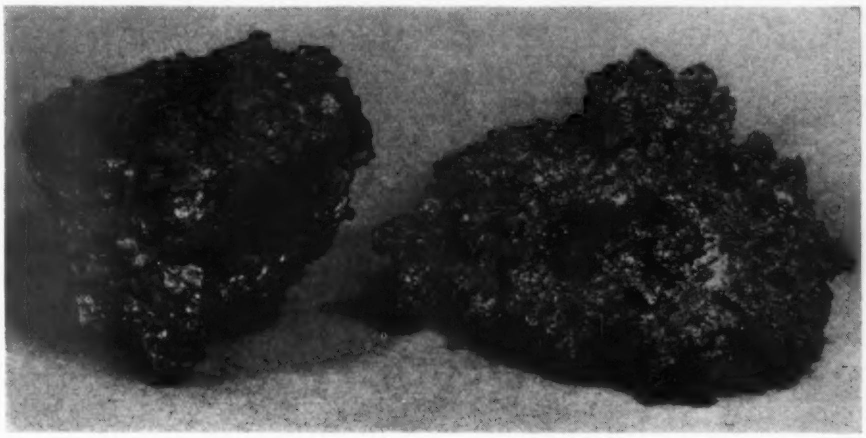
2. The fluid temperature has been raised several hundred degrees above the softening temperature.

The original study of ash control was made with Illinois coals, but later was extended to include two southern Indiana fifth vein coals. These conformed perfectly to the general rules laid down for Illinois coals. Inasmuch as the coals from both states are generally similar, it is believed that the principles would apply to all bituminous coals of equal rank. Three years' experience, in hundreds of cases, has definitely proved the value of the silica treatment.

An excellent idea of the change in characteristics can be obtained from the photograph of the clinkers, Fig. 6, showing both treated and untreated coal.

The silica is added in the form of Ottawa sand. After hand-treating several carloads by hand and getting a perfect check on the smaller tests a proportioning device was designed in which an electrically operated vibrator shakes a controllable quantity of sand onto the belt carrying the coal. The capacity of the belt is known and

Fig. 6 — Clinker from untreated coal at left and from coal treated with 4 per cent silica at right



When fluidity is produced and liquid slag runs down to the grate, the ferric portion of the slag attached to the grate then picks up an atom of iron and becomes a molecule of ferrous oxide. When a grate bar thus burned is broken transversely, the thin film of iron oxide is plainly apparent. If the slag is then forcibly detached from the bar, this film of oxide comes away with the slag and a fresh surface of iron is again exposed. A few repetitions and the bar is destroyed.

Turning to the other case, wherein 4 per cent of silica has been added, a radically different result is observed. The coal may start to soften at exactly the same point as it did in the other case, but instead of immediately liquefying it merely gets a little softer. The ash particles gradually settle down into contact with adjacent particles, forming a spongy, porous mass. By this time the combustibles have disappeared, heat generation has ceased and the mass freezes into the light, porous mass characteristic of coal thus treated. Two things have happened:

1. The high oxides have been transformed into silicates.

the proportioner is operated so that any percentage of silica from $^1/_2$ to 6 per cent may be added. For the past $2^1/_2$ yr upwards of 2000 tons of coal per day have been so treated.

Conclusions

In view of the foregoing, it is the author's opinion that,

1. The standard practice of judging the clinkering tendency of these coals by the softening temperature of the ash is definitely wrong.
2. The controlling influence in the production of objectionable clinkers is not the softening point of the ash, but the point of fluidity or the spread between the softening and fluid temperatures.
3. The acid-base ratio of the ash offers a fairly reliable index of the character of an ash.
4. The destructiveness of an ash, relative to the iron of a grate surface, is definitely a consequence of the basic or acidic nature of such ash.
5. Means are indicated for the control of ash characteristics by the addition of silica or lime to vary the several fusion temperatures as desired.

Putting a New Boiler in Service

By ALAN RUCH

Service & Erection Dept.
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A review of the procedure to be followed in examining and checking various parts of a steam generating unit and its auxiliary equipment, together with the boiling and drying-out process, preliminary to placing it in operation.

WHEN erection of a new boiler is in the concluding stages, it is time for the operating department to move in. At this time attention to small details will prevent endless trouble and perhaps forced shutdowns after operation begins. Some of these are as follows:

As the auxiliary equipment has been exposed to many hazards of dirt, dust and rough handling in shipment and erection, the cost of opening and washing all bearings of fans, pumps, motors and turbines is well repaid. All flexible couplings should be checked to see if they are correctly lubricated and it is not a waste of time to recheck them for alignment.

The boiler should be examined inside and out. Drums and tubes should be gone over carefully to make sure that no bolts, rivets or stray tools have been left behind, as such extraneous material, if overlooked, has the bad habit of turning up later in a blowdown or a safety valve. In this connection, it is important that the baffling in the drums be inspected to see that there are no loose or missing bolts and that all joints and flanges are tight.

After thoroughly examining the inside of the boiler the outside should be gone over. Make certain that the safety-valve exhaust stacks are supported in such a way that no strain will be exerted on the valve, for erratic operation will result if the exhaust stacks place a strain on the valves. Exhaust stacks should be as short and straight as possible and the valve drains must be connected properly so that no water can collect above the valve. It is always best to drain the valves through an open funnel instead of direct to a sewer or blowoff tank.

Look at all plugs in the superheater headers, boiler drums and water column connections, especially on units designed for pressures requiring steel fittings. Occasionally during the rush to complete the hydrostatic test a cast-iron plug is used and then forgotten. If one is found later it should be replaced with a steel plug.

Be certain that the superheater drains are piped correctly. These drains should be piped the full size of the header drain valve and permit free blow during the warming-up period. A proper air vent on the steam drum is important.

Next examine all the blowoff connections, feed lines and drain lines to be sure they are supported properly in order that vibration in service may be avoided. Blowoff lines must be supported or guided so that the expansion of the boiler and water walls will not put a strain on the joints. Do not overlook the fact that modern high-set, high-pressure units will expand one or two inches from cold to hot. Such units are usually suspended from the top so that expansion is downward, but this should be checked.

The setting should be examined carefully. Check clearances left for expansion at all pressure parts. It is good practice to establish gage marks on the lower drums and lower water-wall headers, locating all in their cold position in reference to a convenient fixed point in the supporting steel. The gage marks are used as the boiler is warmed up to determine whether or not the drums and headers are expanding uniformly. Failure of any part to continue its movement as the pressure increases can then be investigated and corrected before trouble develops. After thorough examination of the boiler is completed the unit is ready for drying and boiling out.

Drying and Boiling Out

Modern gage glasses are ruined by deposits of oil and dirt collected during the boiling out. They should be replaced by temporary gage glasses during this period.

The boiling-out solution recommended in the A.S.M.E. Rules for Care of Power Boilers is ordinarily used. There are also some suitable compounds marketed for boiling out that may be used if desired.

Modern steam generators contain little refractory in comparison with the old type brick-set boilers. The refractory that is used is not subjected to the extreme temperatures encountered in the brick set boilers; hence the time required for drying out is much shorter.

For boiling out, the A.S.M.E. Rules advise holding the steam pressure below ten pounds. However, as present-day high-pressure high-set steam generators with water-cooled furnaces have rather long complicated circuits through the boiler and water walls, it will be found that the steam pressure may have to be raised to as much as 200 lb in order to create sufficient circulation to do the job.

Superheater drains should be left wide open during the drying and boiling-out period. Besides protecting the tubes from possible overheating the steam generated aids in creating circulation in the unit.

The fuel to be used during boiling out is of considerable concern. Wood fires are ordinarily impractical in large pulverized-coal-fired units. Coal firing is also impractical on direct-fired units because the fire cannot

be maintained at the low rate required. Gas, the least troublesome fuel for the purpose, is not often available so that the choice is usually oil. Many of the large units installed recently are equipped with a permanent oil-burning system for starting up and for standby service. This is suitable for boiling out.

Furnace temperatures during the boiling-out period are necessarily low. For this reason it is best to use light oil and steam or air atomizers to eliminate difficulty with incomplete combustion and smoke.

The danger of unburned oil collecting in the air preheater, induced-draft fan or breeching is quite real. Therefore burners must be watched continually to be certain that combustion is completed in the furnace. If soot blowers are installed on the air heater it is advisable to have the piping to them completed and to operate the soot blowers at frequent intervals.

Single- or multiple-retort stoker-fired boilers can be dried and boiled out with the stoker held on a banked fire. Go over the stoker-drive mechanism carefully, check the lubrication and run the stoker cold for several hours to insure that everything is in proper working order, before running in a charge of coal and lighting off a fire. Care must be taken to keep the fuel bed built up by running the stoker intermittently so that no fuel is burned in the retorts as damage to the tuyères will result.

It sometimes is expedient to burn wood during the drying out, if a large quantity of scrap lumber and crates must be disposed of. The only doors large enough to fire this material are usually over the stoker dump trays or the clinker grinder. Run the stoker full of cinders and cover the dump trays with perhaps four to six inches before starting the wood fire. If a clinker grinder is installed fill up the ash hopper deep enough to prevent any damage. After the drying and boiling-out operation is completed and the fire burned out dump the ashes and clean off the stoker to get rid of all nails and other similar material.

Chain grates and traveling-grate stokers can be handled with little difficulty if bituminous coal is to be burned. Check over the stoker and see that it is lubricated according to instructions and run it cold for several hours. Check the chain tension and adjust if necessary. Check over the alignment of drive sprockets and the chains. The chain should break easily over the drive sprockets and at the take-up end. A tight chain will give trouble later as there will be a slight growth of the links which will tighten the chain and over-balance the tendency to loosen by wearing. On traveling-grate stokers having bars and keys one or more keys, according to the stoker width, should be removed. The bars are ordinarily shipped with the keys packed on tight to reduce breakage and keys must be removed to allow for growth in service.

If bituminous coal is to be used for the drying and boiling fire, the stoker is operated in banked condition with a deep fuel bed using only enough air to keep the fire alive. The stoker is run intermittently as fresh fuel is required, usually a fuel bed over one or two compartments being sufficient for the purpose.

Where scrap lumber is used for drying and boiling out a unit fired with this type of stoker, drop the front of the fuel hopper and raise the coal gate to its maximum height. The wood is then fired through the open coal hopper as required.

A traveling-grate or chain-grate stoker installed to burn anthracite or coke braize may present some difficulty as it is rather troublesome to maintain a low fire in a cold furnace with these fuels. The coal-handling system may be arranged in such a way that it is not practical to put bituminous coal in the bunker for the drying and boiling period. If scrap wood is not available and bituminous coal can be secured but not elevated into the bunker it is possible to hand-fire coal by dropping the stoker coal hopper front and raising the coal gate. Avoid stirring up the fire with a hook or slice bar since very little air is being admitted through the grate and the keys or links are easily burned. Anthracite may also be successfully hand-fired in this manner.

The drying and boiling-out period is an excellent time for the operators to familiarize themselves with the control equipment, the auxiliaries and the locations of the steam, feedwater and drain lines. It is advisable if not imperative to have the combustion control completed at this time at least to a point that will permit remote manual control of the uptake and forced-draft dampers. This is especially true of large units having high draft losses as it may be necessary to roll the fans; hence control of the dampers is needed.

After the boiling-out period is completed the boiler should be drained and washed out. Make a careful examination of the entire boiler and water wall system to be certain that all grease and oil have been removed before capping up for regular operation. The boiling out should be repeated if any oil is found.

Initial Operation

Initial operation in plants in which the new boiler operates in conjunction with existing boilers already in service is ordinarily fairly simple in that it is necessary only to bring the boiler up to header pressure, then pick up load as desired. If conditions arise that require shutting down, the old units are available and little inconvenience results.

If the boiler is the only unit in a new isolated plant there is nothing to fall back on when it begins to carry load. Forced shutdowns are apt to be expensive in such plants. Fortunately, there is an initial period of light load operation while the steam lines are blown out and warmed up and the generator is being dried out. The operators can use this preliminary period to good advantage familiarizing themselves with the operating details and checking all auxiliaries, making every effort to avoid a forced shutdown after the load is being carried.

The size of a boiler and its operating pressure determines the time required to warm up to normal operating pressure. It is the opinion among most operators of large high-pressure units that the rate of firing should be regulated to raise the steam pressure to about 250 lb in the first two hours and to 1250 or 1450 lb in the following two hours.

In the case of small low-pressure units operating at around 250 lb, one to one and one-half hours are sufficient. This is a simple procedure where oil or gas is used as an auxiliary fuel. If this is not the case and direct-fired pulverizers must be used, intermittent firing is ordinarily resorted to. For the intermittent firing a schedule is worked out, based on the experience with each unit, under which the coal is lighted off and fired for a definite number of minutes then cut off for a definite

number of minutes, the schedule being adjusted so that the actual time consumed in bringing the unit to working pressure compares with those mentioned in the preceding paragraph.

Where the unit has an economizer, attention must be given to it during the warming-up period to prevent steaming in the economizer tubes. If steam is generated as the boiler is warmed up a violent temperature change takes place as the boiler goes on the line and the flow of feedwater is started. The temperature shock, while not particularly serious in a welded joint design, may cause leakage in rolled-joint or flanged-joint economizers. Severe water hammer may also result if the economizer generates steam during the warming-up period.

It is usually found that sufficient protection is possible by adding small amounts of feedwater at regular intervals during the warming up, blowing the boiler down as required to hold the proper drum level. Occasionally, a circulating pump is installed to provide a continuous flow of water during the warming up, the pump suction being taken from the lowest drum and discharge to the economizer inlet header.

In the first days of operation anything can happen and often does. Continuous operation depends on many insignificant-appearing auxiliaries. Failure of any one may force a shutdown or make operation difficult. An operating department that has carefully studied and inspected its new equipment beforehand suffers least during this period.

Measuring Pulsating Flow

By WILLIAM MELAS
Cochrane Corporation

REGARDLESS of the type of flow-meter used, where there is pulsating flow involved, it is generally impossible to obtain readings which are directly proportional to the rate of flow. However, precautions may be taken which will reduce the pulsations so that only small errors in the readings will result. Pulsating flow is generally encountered in systems where reciprocating engines, pumps and compressors are used. The intermittent action of such units creates pressure and velocity waves in the fluid, whether it be liquid or gaseous. The waves or pulsations invariably increase the flowmeter readings, not because of the oscillation of the pen back and forth on the chart, but because of the inability of the recorder to follow accurately each pulsation. It is highly important that pulsations be damped or eliminated in order to measure the flow accurately.. Arrangements are recommended which successfully neutralize the pulsations and result in highly accurate readings.

Orifice on Suction Side of Reciprocating Pump

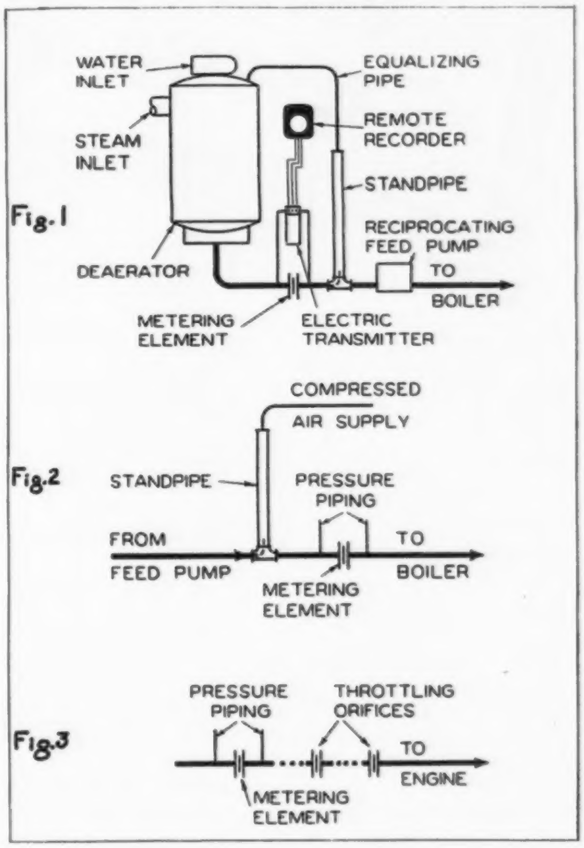
Fig. 1 shows a method of accurately measuring water taken by a reciprocating pump from an open feedwater heater or other receptacle having a free water surface. A standpipe located between the pump and orifice is vented back to the heater and absorbs the pulsations created by the pump. While the water level in the standpipe rises and falls, due to the pulsations, the flow through the orifice remains fairly constant and allows the meter to respond to a head corresponding to the average flow.

The vent line from the standpipe leads to the space above the free liquid level in the vessel supplied. Where this is impracticable, the standpipe or chamber may be supplied with compressed air.

Orifice on Discharge Side of Reciprocating Pumps

When lack of pressure head or other conditions prohibit the orifice being placed on the suction side of the pump, the arrangement illustrated in Fig. 2 can be used. Here the orifice is located on the discharge side.

The water is directed upward into the chamber, where the pulsations cause the compressed air to contract and



Arrangements for neutralizing pulsations

expand alternately. The pulsations are thus absorbed in the chamber and allow accurate readings to be obtained with the flowmeter. This arrangement is also suitable for use in measuring liquids other than water.

Eliminating Pulsations in Steam, Air and Gas

In measuring a compressible fluid such as steam, air or gas, satisfactory results may be attained by installing sufficient receiver capacity and causing the fluid to undergo one or more abrupt velocity changes. This allows the fluid to compress and expand in the receiver space and consequently damps out the pulsations. If a large receiver is not available, "throttling orifices," Fig. 3, may be used to produce changes in velocity. These orifices may be economically constructed of thin sheet metal and inserted between flanges in the line. However, this method results in a pressure loss which is not recoverable, and therefore the use of a receiver may sometimes be preferable.

THE FLASHING CALORIMETER

By A. A. MARKSON, Research Bureau
and Y. A. OLSON, Tech. Service Dept.
Consolidated Edison Co. of New York

The flashing calorimeter is a new instrument for indicating and recording the composition of very wet steam or other very wet vapor-liquid mixtures. It was developed to meet the specific need for a simple device capable of giving information on the composition of steam and water mixtures existing in boiler circuits under various conditions of operation. As such, it has already proved its value in several investigations of circulation in connection with top tube trouble in sectional-header boilers. It is capable of furnishing data on the variation of quality of the mixture in boiler tubes, which is of prime importance in circulation studies.

THE flashing calorimeter is illustrated schematically in Fig. 1. A continuous sample of the mixture is withdrawn through a sampling nozzle such as recommended by the A.S.M.E. The fluid sample expands through orifice *1* into the intermediate chamber *A*, where the kinetic energy is dissipated effectively so that the expansion is a purely throttling process. From chamber *A* the fluid escapes through orifice *2* to the atmosphere. If the inlet pressure is constant and certain precautions are observed in the design of the orifices, the intermediate pressure developed will be a unique function of the wetness of the steam entering the inlet. That is to say, for a given inlet pressure the intermediate pressure will increase in a smooth and continuous manner as the steam gets wetter. To our knowledge this interesting phenomenon was first employed by Campbell to operate a feedwater regulator. In Campbell's regulator, a mixture of steam and water is taken from the water column to a similar two-nozzle chamber. As the water rises in the boiler, the sample becomes wetter and the resulting rise in intermediate pressure is used to throttle the feed valve to the boiler.

The idea of developing this principle into a quantitative measure of steam quality was advanced by the authors because of the many advantages such a device would possess in practical use over a separating calorimeter. The ability to obtain a record of conditions is an outstanding feature as well as the elimination of weighing and volumetric devices.

Before proceeding with this description, it is well to point out that the instrument is not designed to supplant the throttling calorimeter for low percentages of water in steam, even though the throttling calorimeter becomes theoretically useless at pressures in excess of 1800 lb abs. As a practical matter the throttling calorimeter decreases in usefulness once the pressure of 575 lb is passed because of decreasing enthalpy of the vapor. Nor is it designed to supplant conductance methods of calorimetry since its sensitivity is low in the region of 0 to 30 per cent moisture. From a moisture content of about 30 per cent on, the sensitivity of the flashing calorimeter becomes noteworthy, increasing as the steam becomes wetter. The sensitivity over the entire range improves as the pressure condition increases. This is a desirable characteristic. Thus there is no practical or theoretical upper limit of pressure at which the calorimeter will fail to work.

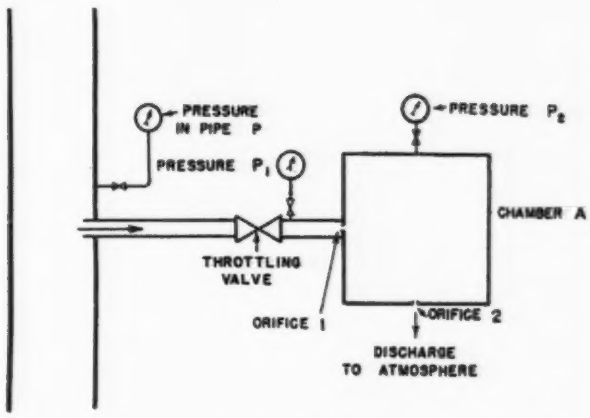


Fig. 1—Schematic diagram of flashing calorimeter

Since the theory of this simple device is more involved than the practice itself, the authors have thought it advisable to describe the actual instrument as designed and used by them. Fig. 2 is a working drawing of the instrument which was tested. The first instruments built were little more than crude pipe fitting affairs. Nevertheless, these gave fairly good results.

Steam enters the inlet which is tapped to take a $^1/_2$-in. nipple. It flows past the inlet thermometer well into the inlet chamber to the high-pressure orifice. The inlet pressure tap is shown as a drilled passage. The steam expands into the intermediate chamber, which has connections as shown for a thermometer and atmospheric free blow. These connections are provided so that the instrument may also be used as a throttling calorimeter for checking the steam point. The steam reverses and exhausts through the outlet orifice to the atmosphere. The pressure connection for the outlet orifice is shown drilled into the exhaust chamber. For best results the instrument should be covered with a thin layer of asbestos or fiber glass and lagged. Both orifices are removable.

In use, the instrument actually is provided with a throttling valve before the inlet so that the inlet pressure

may be held at any predetermined value, thereby eliminating much tedious computation. The line or boiler pressure is then also observed, so that the quality measured by the instrument may be calculated more conveniently and then referred to the line condition. The instrument should be calibrated at the operating inlet pressure.

Having sized the orifices by the methods to be shown, the indication of the instrument is read on fairly dry steam as verified by a throttling calorimeter, or by other methods, and on a sample of saturated water which is initially flashed so that it contains a known amount of steam. These two readings are used to determine the instrument constant from which a curve is calculated giving quality as a function of intermediate chamber pressure for a given inlet pressure.

depend on the truth of any assumptions as to the critical or non-critical nature of the flow through the orifices or nozzles. Such assumptions, however, will be made in the development of the theory of the instrument, and justified by experiment. Its operation is based on a little-discussed principle of thermodynamics. It is well understood that when a perfect gas is throttled without doing any external work, the internal energy is unchanged. Since the enthalpy is also unchanged and is equal to the internal energy, E, plus the product of the pressure and volume, PV, the perfect gas in being throttled must follow the law that for any terminal pressure $P_1V_1 = P_2V_2$. Dry steam, as may be verified conveniently on an Ellenwood chart, when throttled at constant enthalpy, obeys this relationship very well.

However, when wet steam is expanded in a throttling

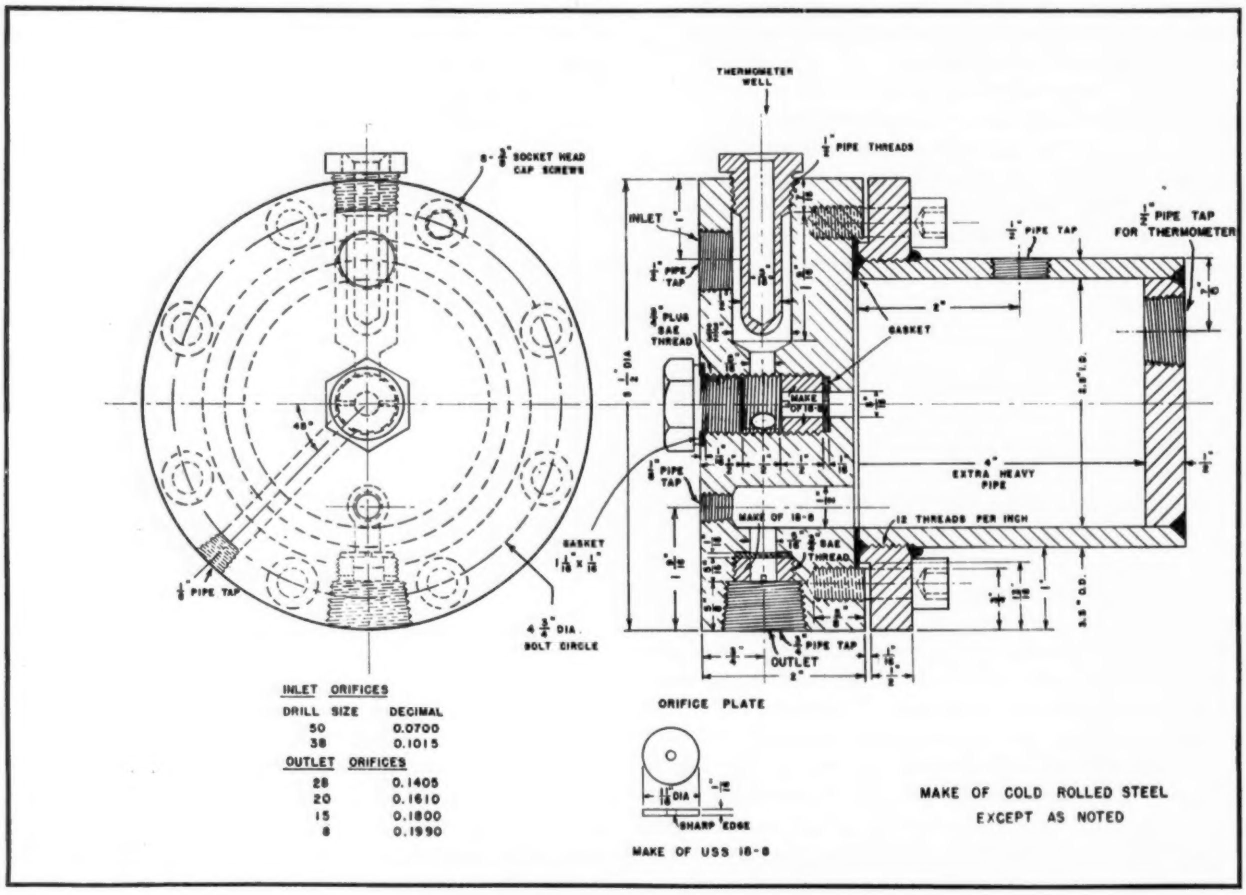


Fig. 2—Working drawing of calorimeter

In recording mixture variations, a two-pen pressure recorder parallels the indicating gages employed. Gage snubbers are generally required on the very wet mixtures, because occasionally the pressure variations may be very rapid. Using the orifice ratios recommended, such variations are not due to separation in the instrument because the atomization taking place is so thorough that it produces a fairly homogeneous mixture.

Theory and Calculation of Quality

Although it may seem that the operating principle of the flashing calorimeter depends in some way on the density relationship in wet steam mixtures, this does not turn out to be of prime importance. Nor does operation

process, this relationship no longer holds because latent heat changes are encountered. Thus, for wet steam, P_2V_2 will usually be greater than P_1V_1. For a given set of conditions this will cause the intermediate pressure to be higher than for dry steam.

In the authors' treatment of the calorimeter, the orifices are selected so that the intermediate pressure is less than the critical back pressure for the high-pressure orifice and still is high enough with respect to the atmosphere so that critical flow will be induced through the low-pressure orifice.

With respect to the theory of critical flow through nozzles it should be recalled that the critical pressure ratio in a nozzle is a function of the ratio of the two spe-

cific heats of the fluid. $\lambda = Cp/Cv$. That is,

$$\frac{P_c}{P_1} = \left(\frac{2}{\lambda + 1}\right)^{\lambda/(\lambda - 1)}$$

For a gas having $\lambda = 1.4$ the critical ratio is the well-known 0.528. Except for the phenomenon of super-saturation, saturated steam acts as though the ratio were 0.58, corresponding to $\lambda = 1.135$. In practice, departures from perfect gas theory are commonplace. The value of such theory in the present instance is that of a framework for subsequent development.

Experimentally, it was found that some erratic results were obtained with fairly wet mixtures on pressure ratios much in excess of 0.5 so that it is quite advisable to work with this pressure ratio as an upper limit for the present. This seems to be in line with the observation that in a two-phase system the ratio Cp/Cv is decidedly not the weighted mean value.

With respect to the flow of saturated water through throttling orifices, there was much confusion on the subject until Benjamin and Miller prepared a remarkably illuminating experimental paper[1] which practically furnishes the answer to the difficulties. They found that the flow of saturated water takes place as though the index of expansion were unity and therefore, even though the terminal state of flashed saturated water showed an increase of volume, this change of state did not take place in the orifice itself, so that the flow was the same as that of an incompressible fluid.

They further showed without comment, that when 3 or 4 per cent of steam was initially present with the liquid, the flow exhibited decidedly critical characteristics. These results are given in Fig. 9 of their paper. The explanation of these results is that the flow of saturated water takes place in a super-saturated manner until there are sufficient steam bubble nuclei initially present, when the flow proceeds in accordance with the theory of a change of state. It may also be noted that Fig. 12 of their paper brings out an essential difference between the flow of steam through orifices and nozzles. The present authors have found that, due to the use of two orifices in series, such effects seem to cancel out. Either orifices or nozzles may be used but it may well be that the use of nozzles will ultimately prove to be preferable.

The development of the formulas used in obtaining numerical results will next be outlined.

For the flow through orifice *1* (Fig. 1)

$$W_1 = N_1A_1\sqrt{\frac{P_1}{V_1}}$$

likewise, for orifice *2* (Fig. 1),

$$W_2 = N_2A_2\sqrt{\frac{P_2}{V_2}}$$

where W = rate of flow
P = orifice inlet pressure
A = orifice area
V = specific volume of the mixture
N = the coefficient involving λ and the discharge coefficient

[1] Presented at the A.S.M.E. Annual Meeting, December, 1940.

Since W_1 must equal W_2, we arrive immediately at the relationship

$$\frac{P_1V_2}{P_2V_1}\left(\frac{N_1A_1}{N_2A_2}\right)^2 = k \qquad (1)$$

Assuming $N_1 = N_2$, this relationship forthwith gives the approximate sizing of the orifices or nozzles for either the dry steam point or the liquid point:

$$\frac{P_1V_2}{P_2V_1} = \left(\frac{D_1}{D_2}\right)^4 = K \qquad (2)$$

where D is the orifice diameter

Therefore, the selection of an orifice ratio to give a certain intermediate pressure when dry or slightly wet steam enters, consists of reading P_1 and V_1 on an Ellenwood diagram, following across at constant enthalpy to the desired P_2, and reading V_2. The ratio P_1V_2/P_2V_1 gives the fourth power of the desired orifice diameter ratio.

Selection of a ratio that will give the desired P_2 when very wet vapor enters must be done by calculation since the present diagrams for steam do not extend far into the wet region. The authors hope this lack will soon be remedied.

The calculation for the quality at P_2 may be obtained by the familiar expression:

$$h_1 = h_{f_2} + X_2h_{fg_2}$$

where X_2 is the quality at P_2
h_1 is the enthalpy at *1*
h_{f_2} is the enthalpy of the liquid at *2*
h_{fg_2} is the enthalpy of evaporation at *2*

The volumes for very wet vapor must be calculated by the relationship

$$V = X \cdot V_{fg} + V_f$$

where V_{fg} is the difference between the tabular specific volumes of vapor and liquid and V_f is the tabular liquid volume.

Returning to equation (1), this relationship will only be valid if k for dry steam and k for saturated liquid are experimentally of the same magnitude, as this obviously constitutes the practical test of the theory. Since the experimental results to be given show that k is sufficiently constant, the method of calculating X_1 may be based on (1).

Write (2) as

$$\frac{KP_1}{P_2} = \frac{V_1}{V_2} = C$$

$$V_1 = X_1V_{fg_1} + V_{f_1}$$

$$V_2 = X_2V_{fg_2} + V_{f_2}$$

giving

$$\frac{X_1V_{fg_1} + V_{f_1}}{X_2V_{fg_2} + V_{f_2}} = C \qquad (3)$$

X_2 and X_1 are also related by the constant enthalpy relationship

$$X_2 = \frac{h_{f_1} - h_{f_2}}{h_{fg_2}} + X_1 \frac{h_{fg_1}}{h_{fg_2}} \qquad (4)$$

substituting (4) in (3) gives

$$X_1 = \frac{CE - V_{f_1}}{D - CF} \qquad (5)$$

where the constants involve only measured pressures and tabular properties.

Symbol		*Quantity*
X_1	=	Inlet Quality
C	=	$K \frac{P_1}{P_2}$
D	=	V_{fg_1}
E	=	$\frac{h_{f_1} - h_{f_2}}{h_{fg_2}} \cdot V_{fg_2} + V_{f_2}$
F	=	$V_{fg_2} \cdot \frac{h_{fg_1}}{h_{fg_2}}$

While the above calculation is straightforward, it will save computing labor to operate at constant inlet pressure and construct a calibration curve as shown in Fig. 3. This curve also reveals the sensitivity characteristic. This is done by assuming intermediate values of P_2 and calculating the corresponding qualities by equation (5).

Experimental Data

Calibration of any given pair of orifices is necessary to establish accurate values of K, although the fourth power ratio of the inlet orifice diameter to that of the discharge orifice will give a rough approximation.

Calibration should be carried out starting with saturated steam and saturated water ($X = 1.0$ and $X = 0$). Both these conditions are readily available in most steam plants and offer conditions of quality that can be determined accurately without the use of special testing equipment.

To investigate K, saturated water was obtained from the bottom of a condensate receiver which collected the drips in the high-pressure piping at Kips Bay Station of the New York Steam Corporation. The instrument was directly connected to the tank below the water line, and a globe valve was located so as to permit throttling. For each of the four pairs of orifices investigated, saturated water was admitted at full line pressure and when conditions had been established at equilibrium, readings were taken of the inlet pressure and temperature and of the pressure in the intermediate chamber between the two orifices. By throttling the inlet valve, additional sets of readings were obtained at reduced inlet pressures. Since the initial enthalpy remains constant when throttling, it is easy to determine the quality at reduced inlet pressures.

The evaluation of K for water consists of determining the specific volume for entering and intermediate chamber conditions and substitution in the equation:

$$K = \frac{P_2 V_1}{P_1 V_2}$$

A second set of calibration points on steam was obtained in the same steam plant on a downcomer equipped with a standard sampling tube. Occasional checks of the initial steam quality were made by using a standard throttling calorimeter which on calibration, according to the A.S.M.E. Test Code, showed a maximum error of 0.5 F. As in the case of saturated water, the inlet steam was throttled to permit observations at several initial pressures. However, the initial quality was 0.995 at about 275 lb per sq in. absolute, so that below pressures of 195 lb slightly superheated steam was admitted to the calorimeter.

Fig. 4 shows the values of K as determined for the indicated orifice combinations. It will be noted that for combinations having higher values of K, the observed

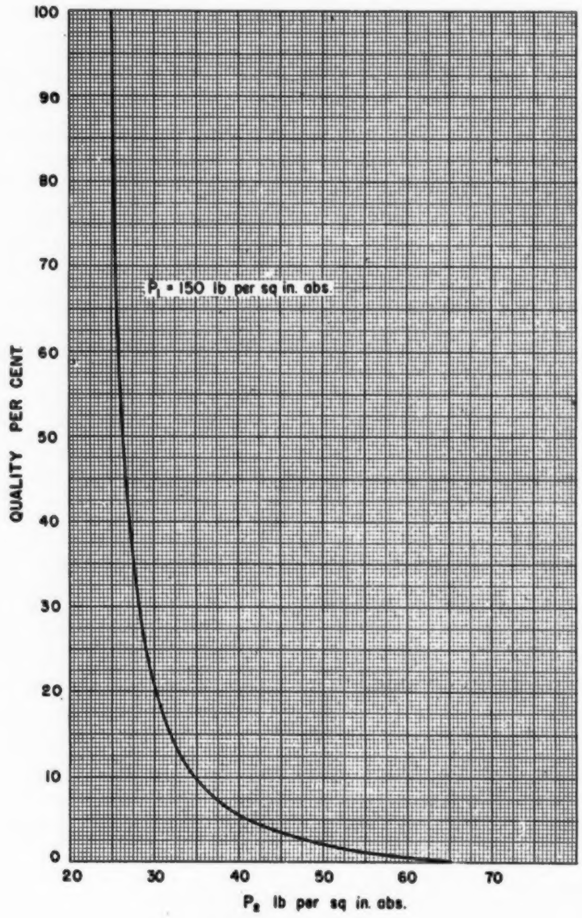


Fig. 3—Calibration curve

difference in K for water and steam increases. By the nature of the theoretical considerations from which these points are computed, it is certain that a continuous curve must exist between the extreme values of K. Until additional investigation establishes the exact form of this curve, a straight line is undoubtedly the best assumption. Orifice combinations giving low values of K have the best consistency and consequently should be used to minimize the probability of error. As determined by a curve, K_1 may be used for more refinement than is given by the K mean.

Reasonable care is required, during both calibration and use, that the pressures obtained are within the limits required for critical flow. If very low initial pressures

are used, it may be necessary to exhaust the discharge of the second orifice to a vacuum. This is especially true if the mixtures under investigation have large percentages of steam. On the other hand, if the sample is very wet, then the intermediate chamber pressure may be too high

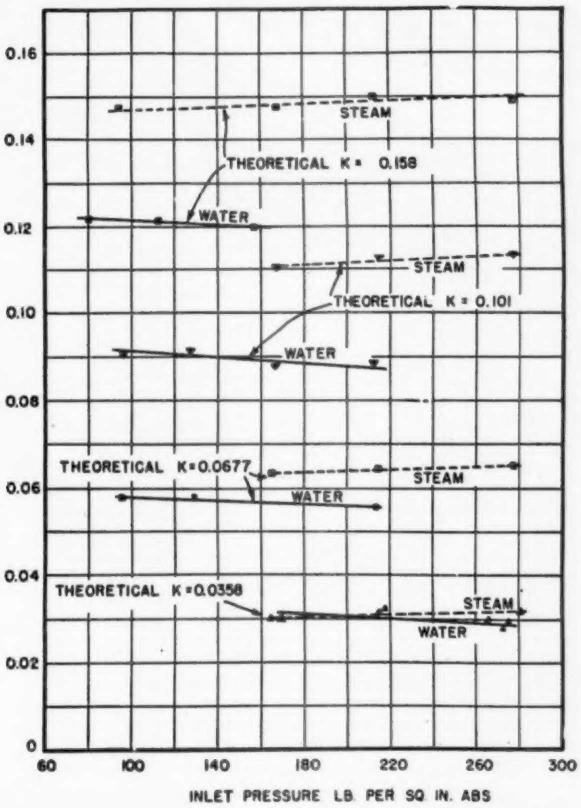


Fig. 4—Values of K for different orifice combinations

in proportion to the entering pressure. In this latter case, throttling the inlet pressure will increase the quality and bring the pressure ratio into line.

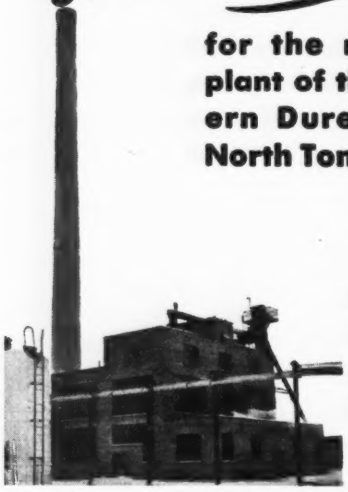
In conclusion, it is believed that a useful instrument has been described, capable of giving results within the probable sampling error. It is obviously desirable that other workers, appreciating the practical simplicity of the flashing calorimeter, make needed contributions to its theory and usefulness.

This work was conducted jointly by the Research Bureau and the Technical Service Department of the Consolidated Edison Company of New York. The authors wish to acknowledge the valuable assistance of their colleagues in this development.

The Board of Directors of the American Association of Engineers has adopted and forwarded to President Roosevelt a resolution asking that the government agencies charged with administration of the Selective Service Act be instructed to place all men with bonafide engineering training and experience, and all regular students of recognized engineering schools, under blanket exemption, deferring service in the Army until the crucial needs of industry for engineers in technological work have been met; also, in order to speed up the defense program, to recall all draftees who by training and experience are professional engineers so that they may return to those industries which need their services.

DUREZ the modern plastic selects the COCHRANE SOFTENER

for the model boiler plant of the ultra-modern Durez factory at North Tonawanda, N.Y.

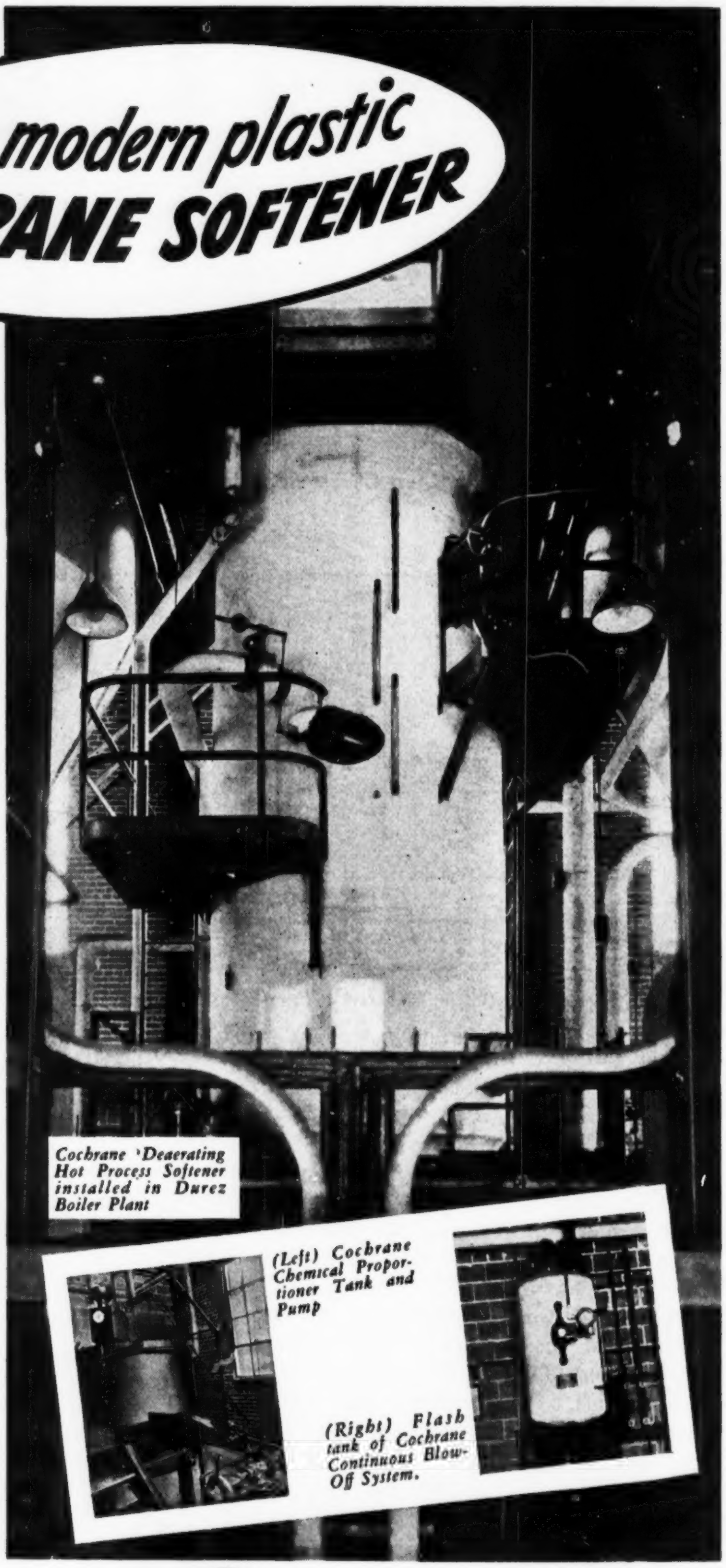


New steam plant for Durez Plastics & Chemicals, Inc., N. Tonawanda, N.Y.

At North Tonawanda, N.Y., the fast-growing business of Durez Plastics & Chemicals, Inc., necessitated the building of a new synthetic phenol plant, which includes a separate building housing the steam plant which furnishes process steam and power.

For feedwater treatment supplying the two 45,000 lb./hr. 2-drum boilers, a Cochrane Deaerating Hot Process Softener was installed. The plant has been in operation since February, 1940, and this feedwater treatment has yielded highly satisfactory results. A Cochrane Continuous Blow-Off System is also a part of this boiler plant, adding the proven economies of continuous boiler blowdown to the many other "planned efficiencies" of this model plant.

Publications describing the type of equipment installed at Durez will be mailed upon request.



Cochrane Deaerating Hot Process Softener installed in Durez Boiler Plant

(Left) Cochrane Chemical Proportioner Tank and Pump

(Right) Flash tank of Cochrane Continuous Blow-Off System.

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STEAM ENGINEERING ABROAD

As reported in the foreign technical press

Power Plant Targets

Engineering and Boiler House Review of March 1941 presents a survey of some of the more important German power plants that have been the subject of recent bombing attacks by the R.A.F.

Heading the list is the well-known Zschornewitz Power Station, located adjacent to lignite fields and feeding the Berlin network over a 100-kv transmission line. This station, originally laid down in 1915 with four boiler houses each containing sixteen boilers, has since been modernized by the installation of six Borsig bent-tube boilers and six of the Steinmueller type, each rated at 132,000 lb per hr and fired by Kraëmer mills.

Another, the Mikramag Station at Magdeburg, is outstanding as a military objective because it supplies important machine tool factories, a large zinc smelter and several aircraft plants. It is stated that up to January 1, 1941, nineteen bombing raids had been carried out in this district. The station is said to contain three 22,500-kw turbine-generators operating at 400 lb, 800 F.

The boiler house of the Bitterfeld Works of the I. G. Dye Trust holds particular interest as it is said to contain ten 1420-lb pressure, 896 F Schmidt boilers, each of 116,000 lb per hr maximum rating. These burn lignite on stokers.

The power requirements of Hamburg, which during 1940 was raided sixty-one times, are met by several important central stations, including the Tiefstack plant containing two 264,000-lb per hr, 1615-lb pressure, 932-F K.S.G. steam generators; the large Schulan Station on the Elbe River and the Neuhof Station containing two 10,000-kw diesel engines.

In the vicinity of Kiel, which was bombed thirty-two times during the same period because of its importance as a shipbuilding center, is located a plant for the testing of naval boilers.

Other important power plants listed as having been the subjects of bombing attack are the station at Holchst containing five Loeffler 1700-lb pressure, 932-F boilers; the well-known Mannheim Station (bombed thirty-four times) and others at Frankfurt and Mainz.

Obviously, no information was contained in this survey as to actual damage inflicted on these plants, although press reports from time to time indicate that German power stations have been hit.

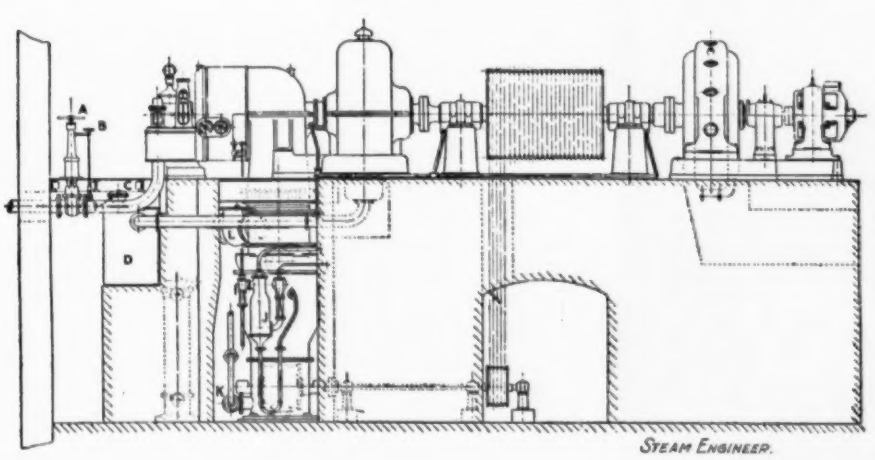
Utilizing Low-Head Heat

How heat in the Limmat River is employed to heat the Town Hall at Zurich, Switzerland, is described in the April issue of *The Industrial Heating Engineer* (London). Although the temperature of the river water never exceeds 60 F, it is used to vaporize freon, a liquid used in refrigeration plants. The freon is then compressed back into a liquid and the heat given off during compression is taken up by water in the radiator system.

This method, by reversal, also permits the radiators to be used for cooling, when desired. By using the river water to absorb heat from the compressed freon, and the radiator-circuit water to provide the heat necessary for vaporization, the water in the radiators will run icy cold. This changeover is possible within a few seconds merely by turning four three-way cocks.

Turbine Rope Drive

The Steam Engineer (London) of March observes that a large proportion of industrial establishments in England are still operated with rope or belt drive of the main shafting from steam engines and suggests that when the time comes for modernization engines be replaced with steam turbines but that all the original rope drive



Typical arrangement for combined rope drive and direct-connected generator

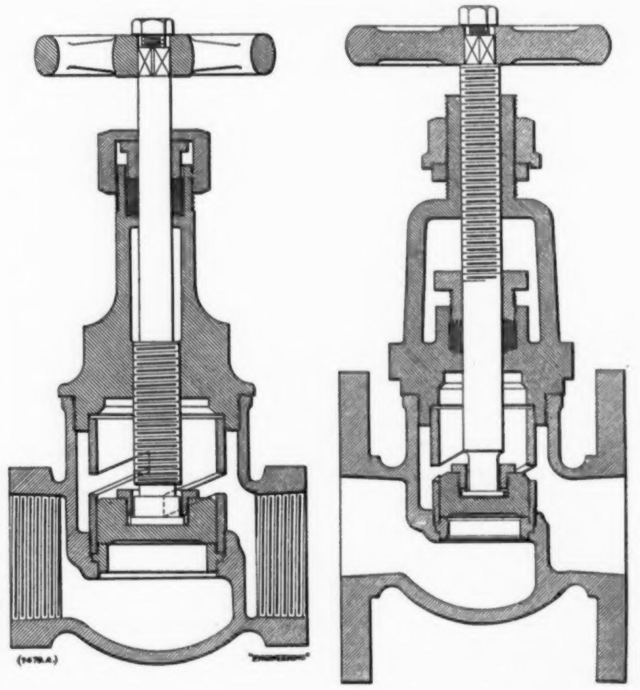
A—Turbine stop valve
B—Stop valve for auxiliary pump
C—Auxiliary oil pump
D—Oil tank
J—Ejector
K—Atmospheric exhaust valve
L—Water ejector

be retained, with the turbine arranged to generate electricity. A typical arrangement that is being supplied for industrial plants by Hick, Hargreaves & Co., Ltd. is shown in the accompanying sketch.

This represents a 2000-hp condensing set, driving a factory by a main rope drive and also direct-coupled to a d-c generator. It will be noted that the air extraction pump is rope driven from the main pulley while for starting up an auxiliary steam ejector is employed.

Seat-In Sleeve Valves

Engineering (London) of February 14 describes a new design of valve intended to eliminate the troubles often experienced in screw-down valves of the disk type when the disk is lifted from its seat by an amount sufficient to permit the passage of only a small quantity of steam. Such close regulation often results in erosion of both the disk and seat.



Valves for saturated and for superheated steam

By referring to the illustrations it will be seen that the seat, instead of opening directly into the body of the valve, opens into a sleeve in which the piston-like disk is a close fit. The sleeve is provided with two helical ports, the bottom corners of which are some distance above the face of the seat. When the disk is lifted it will be well clear of the seat face before any steam can flow. Furthermore, the helical ports provide a fine degree of regulation and any erosion caused by the steam flow is confined to the edges of the ports where it is of little importance. The seat of the valve is of stainless steel and of Tee-shaped cross-section, so that it can be reversed. It is held down in the body by the screwed sleeve, and the disk is loose on the spindle but attached to it by a screwed plug bearing on the spindle collar.

The valve shown at the left is intended for use with

saturated steam up to 150 lb pressure and that at the right for superheated steam up to 300 lb and 650 F. They are designated as "Arkon Seat-In Sleeve Valves."

Transverse Oscillations of Chimneys

In *Wärmewirtschaft* of February 2, 1941, Dr.-Ing. Walther Frank reports the results of experiments made to formulate the frequencies of oscillations of chimneys exposed to winds.

It has been known for some time that chimneys oscillate at right angles to the wind direction and that the amplitude of these oscillations are much greater than those in the direction of the wind. The report reviews earlier findings and shows siesmographic recordings, referring to a film strip showing a chimney describing a rotating movement with its greatest swing at right angles to the wind direction.

Oscillations in the direction of the wind are caused by variations in intensity of wind pressure produced by

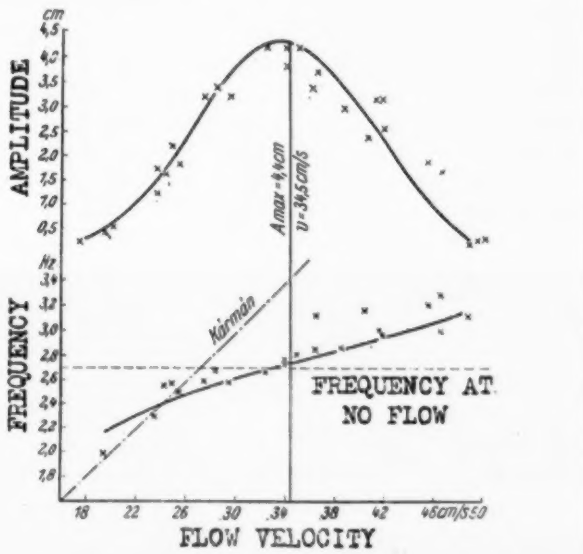


Fig. 1—Amplitude and frequency of a model in relation to the flow velocity

squalls. The frequency of such wind impacts remains constant for only a short time; hence danger of resonance in the structure cannot occur. The oscillations at right angles to the wind direction are explained by the formation and release of Kármán's eddies or whirls. If a circular cylinder is subjected to a uniform flow of fluid there are whirls formed which are alternately released from the cylinder so that one is always offset with respect to the next. This is shown in a photograph (not here reproduced).

The frequency of whirl releases n varies with the velocity of the fluid v and the cylinder diameter d, i.e., $n = 0.2\ v/d$. Each whirl, when releasing, exerts a pressure upon the cylinder at right angles to the fluid flow and by the periodic release of the ensuing whirls the cylinder absorbs pressures which are alternately directed against opposite sides. If the cylinder is inherently elastic or is elastically mounted, it will then begin to oscillate.

To visualize the whirls, experimental cylindrical tubes

were subjected to a flow of water in a model onto which aluminum powder was sprinkled. The tubes were fastened at their bottoms by springs of circular section. Fig. 1 shows the results of an experiment giving the frequency and amplitude in relation to the current speed.

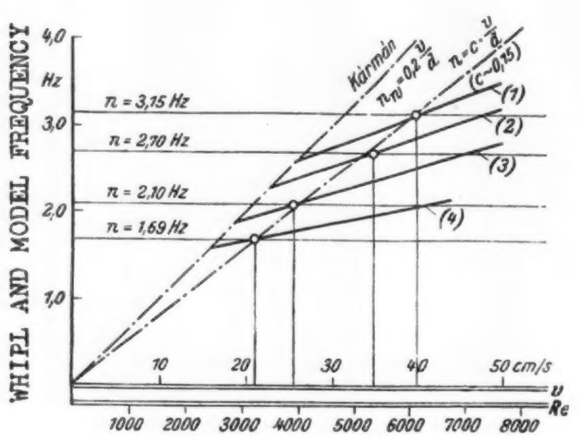


Fig. 2—Whirl and model frequency in relation to the flow velocity and Reynolds Number

It shows Kármán's law as a straight line and the individual frequency of the model parallel to the abscissa. This last frequency is found by oscillating the model in still water. The curves show that with increased water velocity the frequency rises and that the greatest amplitude occurs where the model frequency approaches the frequency for no flow. Kármán's frequency law applies only to cylinders that do not oscillate and varies when oscillation occurs.

Fig. 2 shows the frequencies of four different models. Near the points where the lines of whirl or model frequencies intersect the frequencies for no flow are the values for greatest amplitude and the law for whirl release becomes $n = 0.15\,v/d$.

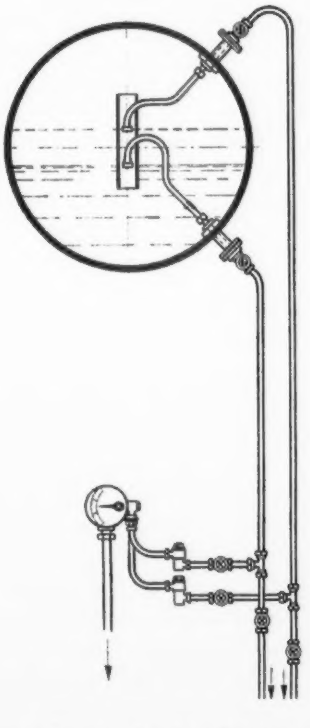
The report then adapts findings from the model experiments to the investigations of chimneys. Even though the experiments were made in water, a comparison seems possible in that the Reynolds Numbers for the experiments and those for the wind velocities which lead to whirl formations are in approximate agreement. A difference occurs in the elastic resistances of the models and the structure.

The report submits calculations for the critical wind velocities of four different chimneys showing that these velocities may frequently occur during storms. Investigation showed that the pressures caused by whirls increased with the square of the velocities and consequently it is advisable to keep the critical velocity law. This may be accomplished by keeping the frequency at no flow low. For example, one means is to keep the wall thickness down for a given height and diameter of chimney. Steel chimneys therefore have greater safety against the occurrence of high critical frequencies. A low frequency is also considered desirable when considering fatigue.

Water-Level Indicator

A new device for indicating the water level in a steam drum, which has been designed to take the place of gage cocks, is described in a recent issue of *Die Wärme.*

In principle this device, or direct water-level indicator, depends upon the different amounts of work done by steam and by water when discharging through a nozzle. When steam expands through a nozzle from boiler pressure to atmospheric, it exerts a definite effective pressure against a blade suspended in its path,



Arrangement of water-level indicator connected to steam drum

whereas the pressure exerted by a jet of hot water from the same or a duplicate nozzle against the blade will be substantially less.

Referring to the sketch, the device consists of high- and low-water connections leading from the drum to two separate nozzles each of which discharges against its own pendant blade located at the indicating gage. These two blades are attached to a common shaft which is attached to the pointer. At normal water level steam flows through one nozzle and water through the other and the combined energy of the jets registers mid-position on the dial. Presumably, the pressure against the blades is counterweighted. At low water level steam will flow through both nozzles and greater energy impinging on both blades will cause the pointer to deviate a maximum amount in one direction. At high water level water will flow through both nozzles and the combined energy will be less, causing the pointer to deviate in the opposite direction.

The indicator may be placed at some distance from the steam drum, the distance being limited by the lag in measurement involved. The loss in water from the boiler is said to be very slight because of the small diameter of the pipes.

The pressure of the jets is, of course, dependent upon the steam pressure within the drum and if this should vary greatly inaccuracies would be introduced, unless the dial be moved to compensate for the variation in pressure. By suitable choice of nozzles the deviating forces may be made great enough to actuate an alarm.

Third Steam Turbine for T.V.A.

A third turbine-generator has been ordered by the Tennessee Valley Authority from the General Electric Company for the new Watts Bar steam power plant, near Chattanooga. Like the first two units ordered last year, it will be rated at 60,000 kw, and will use 850-lb, 900-F steam. The air-cooled generator will turn at 1800 rpm.

The Watts Bar station represents T.V.A.'s first expansion of its power generating facilities by other than hydroelectric development, and is part of a $65,800,000 program to provide power for national defense needs in the area. Hydro facilities are also being expanded under this program to obtain an increase in capacity of 180,000 kw, chiefly for the use of aluminum and nitrate manufacture in the valley.

The first two 60,000-kw steam units, now under construction are expected to be installed by next January, and the third unit by the end of 1942.

EQUIPMENT SALES

Boiler, Stoker, Pulverized Fuel

Boiler Sales

Stationary Power Boilers

	1941 Water Tube		1940 Water Tube		1941 HRT Type		1940 HRT Type	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft	No.	Sq Ft
Jan........	170	968,275	62	285,042	89	123,459	51	68,639
Feb........	102	896,763	54	386,356	81	104,622	47	51,474
Mar........	141	988,927	56	438,980	86	89,324	51	58,529
Jan.-Mar. Inclusive	413	2,853,965	172	1,110,378	256	317,405	149	178,642

* Includes water wall heating surface.

Total steam generating capacity of water tube boilers sold in January, February and March 1941, 29,620,000 lb per hr; in 1940, 12,975,000 lb per hr.

Mechanical Stoker Sales†

	1941 Water Tube		1940 Water Tube		1941 Fire Tube		1940 Fire Tube	
	No.	Hp	No.	Hp	No.	Hp	No.	Hp
Jan............	77	41,975	24	10,770	94	14,036	104	14,745
Feb............	60	27,736	31	10,729	117	14,774	118	17,862
Jan.-Feb. Inclusive...	137	69,711	55	21,499	211	28,810	222	32,607

† Capacity over 300 lb of coal per hr.

Pulverizer Sales

	1941 Water Tube			1940 Water Tube			1941 Fire Tube			1940 Fire Tube		
	No.		Lb	No.		Lb	No.		Lb	No.		Lb.
	N.‡	E.‡	Coal/Hr	N.‡	E.‡	Coal/Hr	N.‡	E.‡	Coal/Hr	N.‡	E.‡	Coal/Hr
Jan......	39	—	462,990	10	—	214,250	—	1	1,000	1	—	600
Feb......	42	4	734,200	15	1	186,935	—	—	—	1	2	2,800
Mar......	29	3	669,700	17	1	317,800	—	—	—	—	—	—
Jan.-Mar. Inclusive	110	7	1,866,890	42	2	718,985	—	1	1,000	2	2	3,400

‡ N—New boilers; E—Existing boilers.

REVIEW OF NEW BOOKS

Any of the books reviewed on these pages may be secured from Combustion Publishing Company, Inc., 200 Madison Ave., New York

Applied Heat Transmission

By Herman J. Stoever

This book is intended for both practicing engineers and students. It puts some of the more important data on heat transmission into readily usable form, and describes the common types of heat-transfer equipment and installation. Emphasis is placed on practical applications rather than on theory.

The chapter headings follow the conventional order but the presentation used is one which will be particularly attractive to practicing engineers who are more concerned with methods of solution than with mathematical derivations. In each section the equations are stated first, the methods of applying them are then illustrated by the solution of numerical problems, and finally the derivation of the equations is explained.

The first three chapters deal with equations required for the solution of elementary problems involving heat transfer by conduction, radiation and convection. Chapters IV and V contain many charts and tables by means of which convection coefficients and the pressure drop values may be quickly and easily determined. The last two chapters are devoted to a description of the more common types of heat-transfer equipment and the kinds of insulation used in industry. Equations for calculating the thickness of insulation required for special conditions of industrial importance are given in the last chapter, together with the application of these equations, which is also demonstrated by the solution of numerical problems. This is a practical book and is amply illustrated with many drawings, charts and halftones.

The book contains 226 pages, including index, bound in dark cloth, size $6^1/_4 \times 9^1/_4$. Price $2.50.

Correcting Oil Burner Deficiencies

By Zuce Kogan

Readers of this magazine may recall an interesting article which appeared in these pages six months ago under the title "Fuel Oil Burning," in which the author, Zuce Kogan, reviewed briefly the concepts on which a widely accepted theory of oil burning was based, and offered a new approach to the problem which modern practice tends to support. To a large degree that article forms a substantial part of the first section of this book, while the succeeding sections, Mixing of Oil and Air, Furnace Heating Zone, Fineness of Atomization and Burner Application, deal more exhaustively with those particular aspects of achieving fast and efficient combustion with less dependence on space, time and refractories.

The practice advocated by the author stresses the need for (1) the proper conditioning of the oil as to pressure and temperature, and that it be effectively atomized by a well-designed burner; (2) the oil to be vaporized and gasified in the shortest possible time by means of high flame concentration; (3) the air to be heated in passing the refractory throat by proper air block design and by the shaping, placing and concentration of the flame; and (4) the oil dispersion and mixing to be achieved by a high air pressure drop through the fuel spray.

The book contains fifteen chapters which include such topics as Air Pressure and Flame Size, Flame Concentration, Air Preheating, Viscosity of Fuel Oil, Proper Burner Sizes, and Burning Range.

Bound in dark cloth the book contains 152 pages with index, and is illustrated with drawings, diagrams and charts. Price $5.

Heating, Ventilating, Air Conditioning Guide for 1941

The new 1941 edition of The Guide, published by the American Society of Heating and Ventilating Engineers, comprises 46 chapters of technical data, much of which has been revised and rewritten to include the latest authoritative information available. A new chapter on the Thermodynamics of Air and Water Mixtures is presented, and in addition to the Bulkeley Psychrometric Chart a new Mollier Diagram for Moist Air is included for use in analyzing air conditioning processes. Chapters on Cooling, Dehumidification and Dehydration, and Refrigeration are also entirely new.

New data on solar heat transmission through walls, roofs and glass blocks will be found in the chapter on Cooling Load, and curves showing measured heat flow into structures replace the theoretical analysis given in previous editions. Information on buses and automobiles is included and reference made to air conditioning of ships and airplanes.

The technical data comprise 832 pages, and the Catalog Data Section in which much useful information has been supplied by manufacturers comprises 312 pages. The handbook contains the Roll of Membership of the Society and complete indices to Technical and Catalog Data Sections. Bound in a flexible blue cover; price $5.00. Thumb-indexed copies—$5.50.

1940–1941 Standards on Coal and Coke

This volume is issued under the auspices of the American Society for Testing Materials' Committee D-5 on Coal and Coke and combines in convenient form all the A.S.T.M. tests, definitions and specifications for coal and coke. Four items in the book cover sampling; other items include two grindability tests and other procedures, tests for size (anthracite), sieve analysis (crushed bituminous), cubic foot weight and a proposed agglutinating value of coal. Specifications for coals by rank and grade are also included, together with a section devoted to coke.

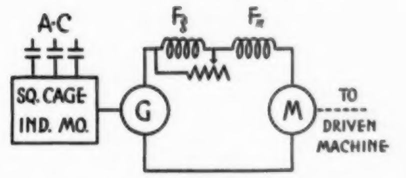
This book contains 135 pages; price $1.25.

NEW EQUIPMENT

Adjustable-Speed A-C Drive

Designed especially for industrial applications requiring smoothly adjustable speeds over wide ranges with constant torque, in locations where only a-c supply is available, a new 10-to-1 adjustable-speed drive, which uses a series circuit without the usual exciter, is announced by the Westinghouse Electric & Manufacturing Company. It is available in ratings from 1 to 15 horsepower with a standard speed range of from 175 to 1750 rpm, for 2- or 3-phase operation on 220-, 440-, 550-volt, 60-cycle systems.

The new drive has five parts, including control. A single-unit motor-generator set, consisting of a squirrel-cage induction motor driving a series d-c generator, supplies operating voltage for a d-c series

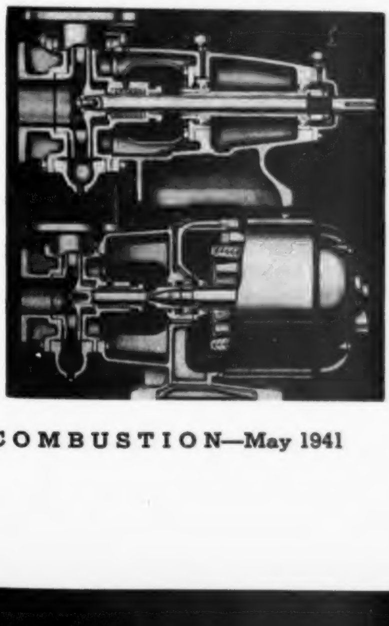


motor coupled to the driven load. In parallel with the generator series field is a rheostat which controls the driving-motor speed. The control apparatus consists of an across-the-line starter for the squirrel-cage motor and a push-button station.

The new drive is more flexible than the wound-rotor motor and is more efficient than the conventional variable-voltage system because it has no exciter rotational losses. High-torque characteristics of the d-c series motor are combined with the flat-speed properties of the shunt motor to give good speed-torque characteristics.

Centrifugal Pumps

Micro-Westco, Inc., which heretofore has been identified with the production of turbine-type pumps, has lately brought out a line of centrifugal "Westco" pumps.



These are in two series, one having flexible-coupling drive (upper view) and the other built as a unit with the driving motor (lower view). The former is offered in sizes from $1\frac{1}{4}$ to 6 in., inclusive. It will be observed by reference to the cutaway illustrations of these two types that side suction is employed, there is a tapered fit between shaft and impeller and that ball bearings are provided.

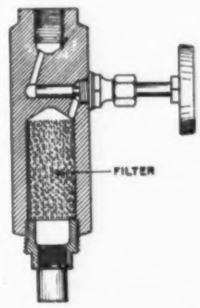
Carryover in Boiler Condensate

Industrial Instruments, Inc., has developed an electrical device which gives automatic warning of excessive carryover in boiler condensate. This instrument actuates an external warning device such as a flashing lamp, ringing bell or recorder. It can also be applied to the operation of an electromagnetic valve or other mechanical device.

In the typical installation a small steam pipe is brought from the boiler to a simple condenser. The condensate is passed through a vertical pipe which has the conductivity cell at the bottom. The cell is wired to the solu-bridge controller which may be suitably located alongside the warning means. Both analytical and control functions are handled by the same instrument.

Pulsation Dampener

J. A. Campbell Co. announces a new device to eliminate "jitters" from the gage hand. The device is known as the Campbell Micro-Bean and can be installed on the pressure line to the dia-



phragm of a pump governor for the protection of pressure gage mechanism, or to any control valve. The Micro-Bean consists of a solid brass body in which a filter protects a slightly tapered valve. The slight taper minimizes the tendency to pinch off under changing pressure conditions and the micrometric control of the opening enables the operator to obtain the closest approach to full shutoff down to the last 0.0003 of an inch, it is claimed, regardless of line content. The valve will handle steam, fuel oil, gas, water or other liquids, with simple adjustment for each viscosity. The device is universal in application up to 3000 lb pressure.

Plastic Gage Dial

In view of aluminum being at present one of the vital national defense materials, particularly in aircraft production, the Ashcroft Gage Division of Manning, Maxwell & Moore, Inc., has brought out a new plastic gage dial. These dials are made with the graduations sealed between layers of clear plastic, the face being pure white without gloss and the markings jet black. They are claimed to have an advantage over aluminum dials in that they can be readily washed and they will not corrode or crack.

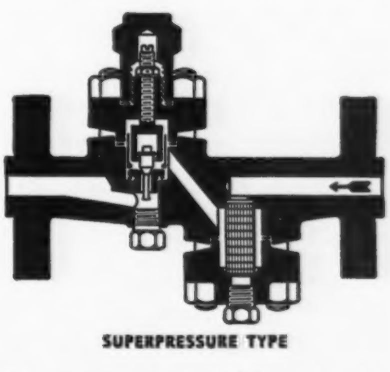
It is estimated that the yearly savings of aluminum to be effected by substituting plastic dials, at the present rate of production, will be sufficient to make available the aluminum required in 350 engines for trainer planes.

Seals for Boiler Setting Tops

The George P. Reintjes Company has developed a new design of drum sealing ring and side-wall construction of tile and brick sectionally supported independent of the side walls for sealing the upper wall settings of water-tube boilers against air infiltration. Provision for expansion is made by the use of sealing rings around the drums and shaped tile bonded into the brickwork.

Superpressure Steam Trap

Yarnall-Waring Company announces a superpressure type trap for high-pressure, high-temperature service. As shown in section it is of flanged-end (or welded socket end) bolted-bonnet design, with integral strainer. The working parts are similar to those in the standard impulse trap in which opening and closing of the valve is governed by changes in pressure in the control chamber above the valve piston. Medium temperature condensate reduces chamber pressure and the



SUPERPRESSURE TYPE

valve opens; whereas high temperature condensate increases chamber pressure and the valve closes.

This trap is built for steam pressures up to 1500 lb and temperatures to 900 F. Pulsating or varying pressures will not interfere with the operation.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request.

Automatic Boiler Feed Systems

This four-page folder describes the Micro-Westco, Inc., line of turbine type pumps and boiler feed units for systems applicable to boiler sizes from 30 to 750 hp and for boiler pressures up to 200 lb. Westco equipment listed includes receivers, strainers, automatic boiler water level control, magnetic starters, makeup valves, pressure gages and thermometers.

Automatic Drainage

A new bulletin has been issued by the Armstrong Machine Works, describing its line of "snap action," ball float and inverted bucket air traps. This four-page folder is well illustrated and contains some useful engineering data on removal of water from compressed air.

Coal and Coke Handling Equipment

Blaw-Knox Company has issued a new 20-page catalog (No. 1807) on buckets for coal and coke handling. Both light and medium weight units are described and generously illustrated with drawings, diagrams and photos. The equipment covered includes: two-line lever arm buckets for crawlers, truck and locomotive cranes, derricks and whirleys; special high-speed tower buckets of the two-line type; and four rope buckets to operate on bridge and gantry type cranes. There are diagrammatic explanations of a number of technical features, an analysis of cable life and a table of bucket capacities.

Continuous Blowoff Equipment

The Permutit Company has released an eight-page bulletin (No. 2391) showing typical arrangements of continuous blowoff equipment. Five diagrams are given showing flash and non-flash systems and two pages are devoted to a more detailed description of flash tanks, rate of flow controller, heat exchangers, etc., which go to make up these systems.

Dispersion Dryer

Advantages of dispersion drying and applications of the method are outlined in a new 8-page bulletin issued by Western Precipitation Corporation of Los Angeles. It is claimed that the turbulent dispersion in high-temperature gases made possible in the "Turbulaire" equipment gives the activated aeration necessary to speed the drying cycle. The field of application includes slimes, pulps and other colloids that cannot be filtered. Installation sizes run from 75 lb to as high as 4000 lb of water evaporation per hour.

Double-Check Softeners

A new four-page bulletin (No. 605) has been issued by the Elgin Softener Corporation, describing its line of double check zeolite water softeners for which claims of high efficiency are made. Enlarged close-up views of nozzles and other design features show how loss of zeolite is prevented, and how faster backwash flow rates are made possible, permitting a deeper zeolite bed and utilizing practically the full capacity of the tank.

Proportioning Equipment

The D. W. Haering & Company line of proportioning equipment has been expanded to include sampling and proportioning arrangements utilizing both chemical pump design and displacement type feeders. These are described in a new 8-page bulletin just issued which gives dimensions, capacities and operating data also installation pictures and diagrams.

Refractories

"Modern Fire Brick Manufacture" is the title of a new booklet issued by the A. P. Green Fire Brick Company, which presents in a dramatic pictorial form the various stages of manufacture carried out at its plant in Mexico, Missouri. Three distinct processes, hand mould, stiff mud and dry press, together with the various grinds and burns, widen the field for the application of a specific brick to meet a specific need. The booket comprises 16 pages of interesting and excellent pictures.

Speed Control

Hydraulic Automatic Control is the subject of a six-page folder just issued by Reeves Pulley Co., Columbus, Ind. Although the hydraulic control is not entirely new, certain improvements have been made, and this bulletin is the most complete presentation offered by Reeves since it was originally announced. This control is used in combination with Reeves Variable Speed Transmission, and, as an example of its wide scope of application, illustrations show installations in the textile industry.

Synchronous Motors

General Electric Company has issued a four-page folder entitled, "How to Start and Protect a Synchronous Motor for Best Results." This is an instructive leaflet demonstrating the use of SCI (Slip-cycle Impedance) Control. The number of folder is GES 2677.

Valves and Fittings

The Reading-Pratt & Cady Division of the American Chain & Cable Company, Inc., has recently issued a new Steel Valve catalog which contains a wealth of useful information presented in a concise but complete manner. It is profusely illustrated, containing outside and cross-sectional views of cast-steel valves and parts, and pictures taken in the manufacturing departments of the plant at Reading, Pa. Chemical compositions and physical properties of metals used are given, together with dimensional drawings and specifications for a particular type of valve of a given pressure rating. Engineering data applying to the selection and installation of cast-steel valves and fittings are also covered in a special section.

Valve Control

The Brown Instrument Company has just issued a new catalog, No. 77-1, describing a line of motor power units and motorized valves designed to operate with Brown control instruments. This 24-page booklet is profusely illustrated. Dimension tables and schematic diagrams accompany each item of equipment listed.

Water Cooling

A new catalog titled "Water Conservation Equipment," just issued by the Water Cooling Corporation, describes the company's line of mechanical-draft cooling towers, atmospheric cooling towers, spray nozzle and roof cooling systems. The company specializes in complete installations of water conservation equipment designed to meet the requirements of municipal authorities and fire underwriters. The principle of the Watco roof cooling system is the dissipation of exterior solar heat which would otherwise be absorbed by the building roof. An installation makes it possible to maintain lower inside building temperatures and reduces the cost of operation of air conditioning systems where used.

Welding

General Electric Company has issued a four-page folder (GEA-569F) describing multiple-operator arc-welding systems for manual or machine welding. The flexibility of capacity obtained by parallel operation of multiple-operator, constant potential arc welders is described and illustrated, and a table giving ratings, dimensions and weights of motor-generator sets is also included.

Items in Brief

The 1941 Convention of the Edison Electric Institute will be held June 2 to 5 in Buffalo, N. Y. The general sessions will be held Wednesday and Thursday in the new Kleinhans Music Hall and headquarters will be at the Hotel Statler.

According to the American Petroleum Institute the additional demand for petroleum products in the United States to meet the "all-out" defense efforts of war, has been estimated as up to 300 million barrels a year, or 20 per cent of present production. This, in addition to the normal demand, it is claimed, can be supplied by the petroleum industry with almost no changes in the present set-up.

Speaking recently before the Missouri Valley Electrical Association, D. S. Snell of the G. E. Turbine Engineering Department predicted that hydrogen cooling would soon be extended to generators of relatively small size. Several of 20,000-kw capacity have already been built with hydrogen cooling and studies are now being made as to its economical application to lower capacities.

The American Welding Society announces that cash prizes totaling $700 are being offered again this year for technical papers on resistance welding in a contest sponsored by the Resistance Welder Manufacturers Association, Philadelphia. The contest closes on August 31, 1941.

Bituminous Coal Research Inc., the research agency of the bituminous coal industry, has announced the inauguration of a $200,000 program of research aimed at advancing the competitive position of coal by the development of better equipment for its use in industry and in the home. The program will be carried on at Battelle Memorial Institute, Columbus, O.

Seventeen technical sessions and approximately 100 papers are scheduled for the Forty-Fourth Annual Meeting of the American Society for Testing Materials to be held at the Palmer House, Chicago, June 23 to 27, inclusive. There will also be an exhibit of testing apparatus and related equipment. Among the sessions that will hold particular interest for power engineers is a symposium on determining steam purity by conductivity methods; another is a paper on carbon-molybdenum pipe for high-temperature service.

The Chief Engineers Association of Chicago through its educational committee, realizing the importance of a knowledge of fuel and combustion engineering, particularly at this time with increase in fuel costs and extra loads on boilers, has organized a combustion class of its members arranged for through the cooperation of the Hays Institute of Combustion, of Chicago.

C.E.C. Promotes Walker and Ebdon

Donald S. Walker, for several years past General Sales Manager of Combustion Engineering Company, Inc., was named Vice President in Charge of Sales at a meeting of the Board of Directors on April 11. Mr. Walker is a graduate of the U. S. Naval Academy, Class of 1924, and for the next ten years was associated

with D. H. Skeen & Company of Chicago, in charge of Ljungstrom Air Preheater sales, becoming vice president of that company and subsequently president of its subsidiary, the Mercon Regulator Company. He joined Combustion Engineering Company in December 1934 as manager of the Philadelphia District. Among the engineering societies of which he is a member are the A.S.M.E., the Society of Naval Architects and Marine Engineers, the Iron & Steel Institute and the Army Ordnance Association; also the Engineers Club of New York.

H. G. Ebdon, formerly Assistant General Sales Manager, has been advanced to General Sales Manager

to succeed Mr. Walker. Receiving his technical education at Cooper Union and at Brooklyn Polytechnic

Institute, followed by several years with the Consolidated Gas Company and the Wilputte Coke Oven Company, Mr. Ebdon joined Combustion Engineering Company in 1917 and has served in various capacities in the engineering and sales work. He is a member of the A.S.M.E. and the Engineers Club of New York.

A.S.M.E. Semi-Annual Meeting

Kansas City, Mo., will be the place of this year's Semi-Annual Meeting of the American Society of Mechanical Engineers on June 16 to 19. Papers will be presented by various divisions on a number of subjects many of which pertain directly or indirectly to power matters. Among these will be several papers under the auspices of the Fuels Division dealing with midwestern fuels, coal handling, pulverized coal and colloidal fuel; and by the Power Division on turbines, lubrication, handling fly ash, welding of boiler tubes, cooling towers, air heaters, plant operation and experiences. These papers are as follows:

MONDAY, June 16, 1941

9:30 a.m.

Qualifications for Operating Responsibility, by Alex D. Bailey
Colloidal Fuel, by J. E. Hedrick
The Firing of Pulverized Coal and Other Fuels Together, by A. C. Foster

8:00 p.m.

Experiences at Des Moines With Large Condensing 3600-RPM Turbine-Generator and Accompanying Boilers, by J. F. McLaughlin
Some Air-Heater Facts, 1926 to 1941, by E. L. Hopping and D. F. Schick, Jr.

TUESDAY, June 17, 1941

9:30 a.m.

Hand-Fired Smokeless Furnace, by Julian R. Fellows and J. C. Miles
Some Recent Chain-Grate Stoker Installations, by F. X. Gilg
Ice Prevention by the Air-Lift System at Grand Coulee, by T. C. Owen
Developments in Regulating Outlet Valves, by G. J. Hornsby
Cooling-Tower Progress, by L. T. Mart
Stability Characteristics of Turbine Oils, by L. C. Welch
Welding of Boiler Tubes, by F. C. Hutchinson

WEDNESDAY, June 18, 1941

9:30 a.m.

Steam-Turbine Regenerative Cycle and Analytical Approach, by J. K. Salisbury
Functions and Requirements of Steam-Turbine Control Systems, by A. F. Schwendner
Coal Handling Systems for Central Stations, by George Daniels
Handling Dust and Fly Ash in Power Plants, by Elmer L. Hughes
Vaporization Inside of Horizontal Tubes, by W. H. McAdams, W. K. Woods and R. L. Bryan
Fort Peck Surge Problems, by F. H. Littrell

THURSDAY, June 19, 1941

9:30 a.m.

Recent Developments in Midwest Strip Mining, by C. Y. Thomas
The Preparation of Stable Non-Slacking Fuel by Steam-Drying Sub-bituminous Coal and Lignite, by V. F. Parry, L. C. Harrington and Arthur Koth

The meeting will be held at the Hotel Muehlebach. Scheduled inspection trips, in addition to points of local interest and power plants, will include a visit to the T.W.A. maintenance shops where airliners are serviced, the Sheffield steel mill, an oil refinery and a strip coal mine.

Personals

W. L. Batt, at present deputy director of the Production Division, Office of Production Management, Washington, D. C., has been awarded the 1940 Henry L Gantt Memorial Medal for "distinguished and liberal-minded leadership in the art, science and philosophy of industrial management in both private and public affairs." Presentation of the medal was made at the Philadelphia Engineers Club on April 22, by W. A. Hanley, President of the A.S.M.E.

Richard Brown of the Boston Edison Company has been appointed chief engineer of steam stations to succeed W. R. Kennedy who has retired. Mr. Brown has been with the company since 1924.

E. R. Crofts, formerly general superintendent of electrical operations of the Rochester Gas and Electric Corporation, has been made assistant to Vice-President Haftenkamp and will remain in charge of operation.

W. H. Doran has recently been appointed vice president of the Metropolitan Edison Company, Reading, Pa. Previous to joining this company he was with the New York State Electric & Gas Corporation as a vice president and division manager of the Ithaca, N. Y., division.

George W. Land has been named research engineer on the technical staff of Battelle Memorial Institute where he is studying methods of treatment of coal to render it dustless.

George J. Nicastro of Combustion Engineering Company has been elected president of the New York County Chapter of the New York State Society of Professional Engineers. He is a graduate of Stevens Institute of Technology, M.E., 1925, and has long been active in the local educational work of the A.S.M.E., of which committee he is chairman. He has also just been elected a member of the Executive Committee of the Metropolitan section, A.S.M.E.

W. A. Perry, superintendent of the electrical and power departments of the Inland Steel Company, East Chicago, Ind., has been elected president of the Association of Iron and Steel Engineers.

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